PB82-229956

Wood Preservative Pesticides Creosote, Pentachlorophenol and the Inorganic Arsenicals (Wood Uses) Position Document 2/3

(U.S.) Environmental Protection Agency
Washington, DC

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U.S. Department of Commerce
National Technical Information Service
NTIS

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Environmental Protection
Agency

Office of
Pesticides and Toxic Substances
Washington DC 20460

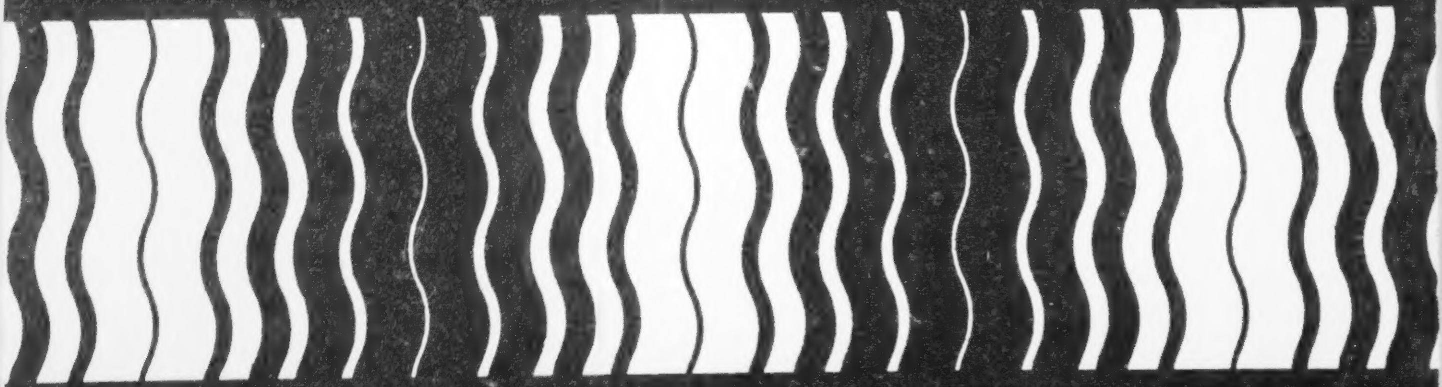
January 1981

PB82-229956

Pesticides

Creosote
Inorganic Arsenicals
Pentachlorophenol

Position Document No. 2/3



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REPORT DOCUMENTATION PAGE

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16. Abstract (Limit: 200 words)

This document details the final determination regarding the the Rebuttable Presumption Against Registration (RPAR) of products containing the above chemical. The responses by by EPA to comments on the preliminary determination by the Scientific Advisory Panel and the United States Department of Agriculture are contained in the document. A bibliography of citations used in this final determination is also provided.

17. Document Analysis a. Descriptors

Wood Preservatives
Position Document No. 2/3

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report)

20. Security Class (This Page)

21. No. of Pages 906

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
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Preparation of this document was completed prior to the January 22, 1982, effective date of the EPA Administrator's Order 2200 and consequently did not necessarily undergo the peer review procedures described therein. The document received peer review according to procedures in place prior to that date and received complete administrative review.

ERRATA: WOOD PRESERVATIVE PESTICIDES POSITION DOCUMENT 2/3

Executive Summary

p.3, 1st para., LL. 5-6: "... from exposure would have to cancel..." should be "...from exposure, the Agency would have to cancel..."

p.8, 1st para., L.2: "TCSA" should be "TSCA."

p.10, 1st para., L.10: "... would expected...." should be "...would be expected..."

Table of Contents

p.7: "PART IV. DEVELOMENT OF REGULATORY OPTIONS" should be "DEVELOPMENT OF REGULATORY OPTIONS."

p.8: "E. Require Special Laundering and Care of Protective Clothing" should be "Require Care of Protective Clothing."

p.10: [3] "b. Risk/Beknefit Impacts of Modifications ..." should be "b. Risk/Benefit Impacts of Modifications..."

I. Introduction

p.2, 1st para., L.2: "This document..." begins a new paragraph.

p.6, 2nd para., L.2: "It combustible and has..." should be "It is combustible and has..."

II. Risk Analyses and Assessments

p.23, 2nd para., L.1: "Risk has two components; the toxic..." should be "Risk has two components: the toxic..."

p.24, 2nd para., L.3: "...asection ..." should be "...a section..."

p.25, 2nd para., L.12: "... (at loug/plate)..." should be "... (at 10 ug/plate)..."

p.43, 5th column, 3rd item: "Papillomas and carconomas" should be "Papillomas and carcinomas."

p.63, 4th para., L.1: "The Agency agrees that the results of the ..." should be "The Agency agrees that the monitoring data in..."

p.88, 2nd para., L.2: "...Lijinskyet ..." should be "...Lijinsky et ..."

ja

p.110, 1st para., L.7: "...effects astrivalent..." should be "...effects as trivalent..."

p.115, title: "Table II.C-1 Cont:" should be "Table II.C-1 Continued."

p.117, 1st para., L.6: "...systems #(*Escherichia coli*)..." should be "...systems (*Escherichia coli*)..."

p.122, 2nd para., L.5: "...this contention The results..." should be "...this contention. The results..."

p.126, 3rd Title: "Summary of Rebuttal Comments Concerning Mutagenicity Conclusion" should be "Summary of Rebuttal Comments Concerning Mutagenicity: Conclusion."

p.127, 1st para., L.3: "162.11(a)(3()(ii)(A)" should be "162.11(a)(3)(ii)(A)."

p.132, column 6, 2nd item: "24, 45, single" should be "24, 45 single dose."

p.133, column 5, 1st item: "$\begin{matrix}9\text{-}10\text{"}\\18\end{matrix}$ should be "$\frac{9\text{-}10}{18}$"

p.133, column 5, 2nd item: "$\begin{matrix}7\text{-}15\\18\end{matrix}$ should be "$\frac{7\text{-}15}{18}$"

p.140, 3rd para., L.2: "...treated with sodium orally..." should be "...treated with sodium arsenate orally..."

p.142, 3rd para., L.11: "...(29,8000..." should be "...(29,800..."

p.143, 2nd para., L.1: "...of pregnant employees was compared..." should be "...of pregnant employees were compared..."

p.146, 2nd para., L.4: "...to wood preservatives and untreated wood..." should be "...to wood preservatives and treated wood..."

p.147, 1st para., L.1: "...of arsenate or arsenites..." should be "...of arsenate or arsenite..."

p.148, 1st para., L.10: "...to befurther investigated..." should be "...to be further investigated..."

p.150, 2nd para., L.4: "...prior to with, which precludes..." should be "...prior to casting, which precludes..."

p.150, 2nd para., L.11: "...*et al*, Being Kimmel and Fowler..." should be "...*et al*., the doses being Kimmel and Fowler..."

ib

p.152, 2nd para., L.10: "...do rabbits..." should be "...doe rabbits..."

p.152, 3rd para., L.3: "...As$_2$O$_5$Kg/cubic foot..." should be "...As$_2$O$_5$/Kg/ft^3 ..."

p.155, 2nd para., LL.1-2: "...in the teratogenicity and fetotoxicity and mutagenicity, risk assessments contained..." should be "...in the mutagenicity risk assessment contained..."

p.155, 3rd para., L.1: "...of the Ronskar smelter..." should be "...of the Ronnskar smelter..."

p.156, 3rd para., L.3: "...significant fetotoxic aand teratogenic..." should be "...significant fetotoxic and teratogenic..."

p.160, 2nd para., L.5: "...workers were, also exposed..." should be "...workers were also exposed..."

p.170, 1st para., L.1: "A number of rebutters stated..." should be "A number of rebutters state..."

p.179, 1st para., L.1: "...after the asenic exposure..." shuld be "...after the arsenic exposure..."

p.179, 3rd para., LL.1-2: "...used 20 ml of apreservative..." should be "...used 20 ml of a preservative..."

p.180, 1st para., L.5: "...of aquaeous arsenic..." should be "...of aqueous arsenic..."

p.188, 2nd para., L.11, missing footnote: "The actual data point used to calculate the exposure was 20 ppm. This number was based on consideration of additional data submitted by AWPI."

p.189, column 1, 3rd item: "House dust (ug/m^3)" should be "House dust (ppm)."

p.195, 1st para., L.2 "...is now estimated at 0.031 ug/m^3..." should be "...is now estimated at 0.0002 ug/m^3..."

p.200, 2nd para., L.15, missing footnote: "The actual data point used to calculate the exposure was 0.002 ug/m^3. This number was based on consideration of additional data submitted by AWPI."

p.201, 3rd para., L.2: "...by the NBS (see rational..." should be "...by the NBS (see rationale..."

1c

p.201, 3rd para., L.6, missing footnote: "The actual data point used to calculate the exposure was 20 ppm. This number was based on consideration of additional data submitted by AWPI."

p.202, 3rd column, 7th item: "2.7-23.1 mg/ft^{26}" should be "2.7-23.1 mg/ft^{2}."

p.202, 4th column, 9th item: "0.031 ug/m^{3}" should be "0.002 ug/m^{3}."

p.202, 4th column, 11th item: "1267 ppm" should be "20 ppm."

p.203, 1st equation: "(Arsenic Air Conc.) X (breathing rate) X (length of time) (wt. of person) = exposure" should be "(Arsenic Air Conc.) X (breathing rate) X (length of time)/(wt. of person) = exposure."

p.205, 2nd para., 2nd equation: "=0.01% of arsenic dermal absorption" should be "=0.01% of arsenic dermal absorption dry dust"

p.209, 3rd para., L.2: "...the MBS..." should be "...the NBS..."

p.209, 3rd para., L.11, missing footnote: "The actual data point used to calculate the exposure was 0.002 ug/m^{3}. This number was based on consideration of additional data submitted by AWPI."

p.210, 1st para., 1st equation, L.3, missing footnote: "0.02 ug/m^{3} X 0.98 m^{3}/hr (light work) X 16 hr + 0.002 ug/m^{3} X 027 m^{3}/hr (resting) X 8 hr/60 kg =0.00059 ug/kg/day or 5.9 X 10^{-7} mg/kg/day.

p.212, 4th major line:

"IV. Resident in As[g] 0.01 0.000021 0.000009 NA NA 0.00003
Treated Homes"

should be:

"IV. Resident in As[g] 0.01 3.3 x10^{-7} 5.9 X 10^{-7} NA NA 9.2 X 10^{-7}.
Treated Homes."

p.216, 2nd para., equation:

$$" \frac{1}{365 \text{ days/yr X } 70} = X^{-5} \text{ of the daily exposure"}$$

should be:

$$" \frac{1}{365 \text{ days/yr X } 70} = 4 \text{ X } 10^{-5} \text{ of the daily exposure."}$$

jd

p.217, 4th major line:

"IV. Resident in
As treated 4.5×10^{-6} 4.0×10^{-6} -- 9.0×10^{-6}
homes"

should be:

"IV. Resident in
As-treated 1.2×10^{-6} 1.1×10^{-6} -- 2.3×10^{-6}.
homes."

p.218, 1st para., LL.6-7: "... was not successfully." should be "... was not successfully rebutted..."

p.220, title: "Chromosomal Abberrations" should be "Chromosomal Aberrations[a]."

p.220, 1st section ("Chromosomal Aberrations"), 2nd Column, Number 2, L.1: "Arsenic, 0.0 -- 100 ug" should be "Arsenic, 0.05 -- 100 ug."

p.220, 1st section ("Chromosomal Aberrations"), 1st Column, "Results," L.6: "... at 0.0 ug -- 100 ug...." should be "... at 0.05 -- 100 ug..."

p.221, 2nd section ("Chromosomal Aberrations"), L.1: "Author Paton and Allison, 1972" should be "Authors Paton and Allison, 1972[b]."

p.221, 3rd section ("Chromosomal Aberrations"), L.1: "Authors Oppenheim and Fishbein, 1965" should be "Authors Oppenheim and Fishbein, 1965[b]."

p.221, 3rd section ("Chromosomal Aberrations"), L.9: "...higher concentrastions...." should be "...higher concentrations...."

p.222, 1st section ("Dominant Lethal"), L.1: "Authors Sram and Bencko, 1974" should be "Authors Sram and Bencko, 1974[b]."

p.222, 1st section ("Dominant Lethal"), L.8: "...TEPA was injected...." should be "...TEPA[c] was injected...."

p.226, 3rd para., L.3: "...trivalent ad pentavalent..." should be "...trivalent and pentavalent..."

p.227, 2nd column, 4th item: "Na arsenite" should be "Na arsenate."

p.228, 2nd para., L.3: "...that long-term expposure..." should be "...that long-term exposure..."

p.229, 3rd para., L.3: "...abnormalities then control populations...." should be "... abnormalities than control populations...."

p.230, 2nd para., L.6: "...the arsenic exppose groups..." should be "...the arsenic-exposed groups..."

p.233, 2nd para., L.2: "...to the affects of arsenic...." should be "... to the effects of arsenic...."

p.233, 2nd para., L.7: "...than, those observative rats...." should be "...than those observed in rats...."

p.243, 1st para., L.9: "...arsenite or arsenite..." should be "...arsenite or arsenate..."

p.245, 3rd column, L.9 (8th item): "128,000" should be " 128,000."

p.263, 1st para., L.6: "...Appendix _____ ...." should be "Appendix 1C."

p.288, 1st para., L.5: "...interiors of homeswere..." should be "...interiors of homes were..."

p.307, 2nd para., L.4: "(California, 1980)" should be "(Mengle, 1980)."

p.368, 1st para., L.4: "...applicable inlight of..." should be "...applicable in light of..."

p.368, 2nd para., L.4: "Additionally, epidemologic..." should be "Additionally, epidemiologic..."

III. Benefit Analysis

p.417, 2nd para., L.4: "...wood perservatives..." should be "...wood preservatives..."

p.440, 2nd para., L.7: "...concrete, masonary and steel framing...." should be "...concrete, masonry and steel framing...."

p.471, 2nd para., L.14: "...perservatives..." should be "...preservatives..."

p.484. This page is missing. It says:

> report lists 2,327 millwork establishments of which only 691 establishments employed 20 or more people. Nearly 42% of all the millwork establishments are located in the Pacific, North Central and Gulf states.

if

According to the 1977 Census of Manufactures preliminary report, the total value of shipments for millwork establishments was $3.9 billion in 1977 (U.S. Dept. of Commerce, 1979c). California establishments accounted for the highest value of shipments, $573.9 million. The 1977 value of shipments for millwork increased about 64% from that of the 1972 value of shipments for millwork. The products primarily responsible for the increase in the value of millwork shipments were wood window units and wood doors.

Total production of softwood plywood (3/8" basis) increased 3% from 19.38 billion square feet in 1977 to 19.96 billion square feet in 1978 (American Plywood Association, 1979). Of the 182 United States mills producing plywood in 1978, 111 mills were located in the Western region. The percentage share of plywood production of Western and Inland* producers has been grad-

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* The definition of producing regions are: 1) Western: California and portions of Washington and Oregon that are west of the Cascade mountain range, 2) Southern: states south of the Mason-Dixon line and from Virginia to Texas, and 3) Inland: all other areas of the United States not defined in Western and Southern regions.

p.502, 2nd para., L.14: "...the currently registed TBTO..." should be "...the currently registered TBTO..."

IV. Development of Regulatory Options

p.560, 1st para., LL.5-7: "At those treatment plants surveyed, 75% of the workers' work shoes are already left at the treatment plant on a required or voluntary basis (Mitre, 1980)...." should be "At those treatment plants surveyed, 75% of the workers already leave their work shoes at the treatment plant on a required or voluntary basis (Mitre, 1980)...."

p.566, 1st para., L.7: "...reduction in residues..." should be "reductions in residues..."

V. Review of the Impacts of Regulatory Options and Modifications

p.576, 1st para., L.5: "...is about 4,000 to 1,400...." should be "...is about 4,000...."

p.585, 2nd para., L.6: "...through arsenic containing water vapors..." should be "...through arsenic-containing water vapors..."

p.589, 2nd para., L.1: "...are often dipped or sprayed with penta..." should be "...are often dipped in or sprayed with penta..."

p.622, 3rd para., L.6: "...already provide to employees..." should be "...already provided to employees..."

p.633, 2nd para., L.1: "implementating" should be "implementing."

p.634, 1st para., L.3: "...Continued Registation without changes..." should be "...Continued Registration without changes..."

p.636, 3rd para., L.4: "...the actual risks encounted..." should be "...the actual risks encountered..."

p.639, 2nd para., 5th item, L.2: "...Application (desginated areas will...." should be "... Application (designated areas will..."

p.646, column 1, 2nd item: "b. Bag Emptyping" should be "Bag Emptying."

p.661, column 1, 2nd item: "Bgg Emptyping" should be "Bag Emptying."

p.671, 2nd para., title, L.3: "...Applications of the Inoranic Arsenicals...." should be "...Applications of the Inorganic Arsenicals...."

p.672, 3rd para., L.1: "During commerical..." should be "During commercial..."

p.673, 2nd para., L.1: "While the primariy exposure..." should be "While the primary exposure..."

p.675, 2nd para., L.6: "...commerical applicators..." should be "...commercial applicators..."

p.676, 1st para., L.13: "...or commerical brush-on..." should be "... or commercial brush-on..."

p.676, 3rd para., L.4: "... commerical brush-on treatments..." should be "...commercial brush-on treatments..."

p.679, 1st para., L.4: "Due to a lack of data, the implementation of this..." should be "The implementation of this..."

ih

p.684, 1st para., L.8: "...of applicaton..." should be "...of application..."

p.687, 2nd para., L.2: "...and sawing pestcide-treated wood..." should be "... and sawing pesticide-treated wood..."

p.687, 3rd para., L.10: "...and gastrointestional exposure..." should be "...and gastrointestinal exposure..."

p.687, Footnote, L.2: "...skin pegmentation..." should be "...skin pigmentation..."

p.689, 3rd para., L.7: "...a fetotoxic MOS for about..." should be "...a fetotoxic MOS of about..."

p.692, 2nd para., L.2: "...of pesticides on wood..." should be "...of pesticides to wood..."

p.701, 1st para., L.4: "...exposure of particulates..." should be "...exposure to particulates..."

p.701, 1st para., L.5: "Wearing these protective clothing..." should be "Wearing this protective clothing..."

p.705, 3rd para., L.1: "... and denial or registration..." should be "...and denial of registration..."

p.712, 4th para., L.6: "...which are in conact with..." should be "... which are in contact with..."

WOOD PRESERVATIVE PESTICIDES

CREOSOTE, PENTACHLOROPHENOL AND THE INORGANIC ARSENICALS

(Wood Uses)

POSITION DOCUMENT 2/3

OFFICE OF PESTICIDE PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY

EXECUTIVE SUMMARY

Wood Preservative Position Document 2/3

contact person: Joan Warshawsky

On October 18, 1978, EPA issued Notices of Rebuttable Presumption and Continued Registration (RPAR) of pesticide products containing coal tar, creosote, and coal tar neutral oils ("creosote"), the inorganic arsenical compounds, and pentachlorophenol ("penta") and its salts. This Position Document (PD) 2/3 proposes several regulatory actions to reduce the human health risks resulting from registered wood preservative uses of creosote, the inorganic arsenical compounds, and penta. These proposed actions are based on the Agency's determination that these uses may result in unreasonable adverse effects. For creosote, the effects are oncogenicity and mutagenicity. For the inorganic arsenical compounds, the effects are oncogenicity, mutagenicity, and teratogenicity. For penta (or its contaminants), the effects are oncogenicity, fetotoxicity, and teratogenicity.

The document considers only the wood preservative uses of these pesticides. For creosote, these uses are pressure treatment (railroad ties, lumber, timber and plywood, pilings, posts, crossarms, and poles), groundline treatment of poles, and home and farm applications. For the inorganic arsenical compounds, the uses are pressure treatment and related uses (lumber, timber and plywood, pilings, posts,

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crossarms, and poles). For penta, the uses are pressure treatment (railroad ties, lumber, timber and plywood, pilings, posts, crossarms, and poles), groundline treatment of poles, home and farm applications, sapstain control (sodium penta), millwork, and particleboard.

In general, the risks to applicators, especially treatment plant applicators, are theoretically very high. Risks to construction workers and to general population applicators and to the general population exposed to end-uses of treated wood are moderate. The benefits from the use of wood preservatives on the large number of treated wood products are extremely high. Moreover, the impacts of the cancellation of all three wood preservatives may have been underestimated since the required social, institutional and technological changes which would be required by full cancellation of preserved wood uses cannot be fully assessed by conventional marginal cost analysis.

In reaching a regulatory position on the wood preservatives, the Agency has considered several important factors: the risk estimates for all three wood preservative chemicals for pressure and non-pressure treatment plant applicators and for certain non-plant uses, the uncertainty associated with the risk numbers, the low number of applicators involved, the extremely high benefits for each chemical, and the non-substitutability of alternative chemicals for certain uses. The Agency is very concerned about reducing the apparently high risks to treatment plant workers. However, canceling a specific use or uses for each one of the three wood preservative chemicals is unlikely to alter the overall risk picture for that chemical, since the treatment plant applicator is likely to apply the chemical to another end-use product. Thus, in order to appreciably lower the risks from exposure would have to cancel all uses of that pesticide. Due to the non-substitutability of the wood preservative compounds and the lack of acceptable non-wood or other chemical alternatives for many use situations, the economic impact which would result from an across-the-board cancellation would be immense. Moreover the only wood preservative pesticides which are efficacious for a majority of the use sites are the inorganic arsenical compounds, which pose the highest level of estimated risk.

In order to achieve significant reductions in risk while retaining the benefits of use to the fullest extent possible, the Agency carefully considered the full range of modifications to the terms and conditions of registration which are available under FIFRA. The Agency selected those risk reduction measures which are cost effective and which will reduce the risk by a significant amount.

The first regulatory action the Agency is proposing is to allow registration to continue for the pressure treatment uses of creosote, the inorganic arsenical compounds, and penta, with changes to the terms and conditions of registration. These are by far the largest uses of the wood preservatives. Specifically, for the pressure treatment uses of all three wood preservatives, the Agency will classify these pesticides for restricted use, and will require that: 1) all applicators wear gloves, 2) all applicators who open treatment cylinder doors wear respirators, 3) all applicators who enter pressure treatment cylinders wear neoprene-coated cotton or rubberized protective clothing and wear respirators, and 4) all protective clothing and equipment be left at the plant. Moreover, the Agency will require the use of closed emptying and mixing systems for all prilled (granular) and powder formulations, the use of a dust mask for individuals working outdoors in arsenical treatment plants, and measures to reduce the surface residues of arsenic on treated wood. In addition, the Agency will prohibit eating, drinking and smoking during the application of these pesticides, will prohibit the application of these preservatives to wood which is intended for interior use, and will prohibit the application of these pesticides to wood intended for uses that may result in contamination of animals, food, feed or water.

The second regulatory action the Agency is proposing is to allow registration to continue for poles-groundline use of creosote and penta, provided certain restrictions are made on this use. The Agency will require that applicators wear resistant gloves and coveralls, that protective clothing be disposed of properly, and that applicators not eat, drink, or smoke during application of these pesticides. Also, the Agency will classify these pesticides as restricted use pesticides.

Next, the Agency proposes to allow registrations to continue (with one exception) for home and farm uses of creosote and penta, provided certain modifications are made to the terms and conditions of registration. These modifications include: 1) classify all creosote products and pentachlorophenol products containing a pentachlorophenol concentration greater than 5% as restricted use pesticides; 2) require that applicators wear gloves and coveralls, 3) require the proper disposal of protective clothing, 4) prohibit eating, drinking and smoking during the application process, 5) require that all certified applicators who use the spray method of application wear neoprene-coated cotton or rubberized protective clothing, 6) prohibit the application of these preservatives indoors and prohibit application to wood which is intended for interior use, and 7) prohibit the application of these pesticides to wood intended for uses that may result in contamination of animals, food, feed or water.

The exception to continued registration for home and farm uses is the spray method of application for penta products containing 5% or less penta. The Agency proposes to cancel the spray application method for these formulations because this application method may expose the applicators to high levels of penta. The Agency believes that non-certified applicators of these products will lack the special training and equipment necessary to spray these formulations safely. Moreover, as these applicators will still be able to apply penta by other methods, this cancellation will provide significant risk reduction without major economic impact.

For the brush-on use of the inorganic arsenicals, the Agency is proposing the continuation of registration with modifications: 1) classify the inorganic arsenical compounds as restricted-use pesticides, 2) require that applicators wear gloves and coveralls, 3) prohibit eating, drinking and smoking during application, 4) require the proper disposal of worn-out protective clothing, 5) prohibit the application of the inorganic arsenical compounds to wood which is intended for interior use, and 6) prohibit the application of the inorganic arsenical compounds to wood intended for uses that may result in the contamination of animals, food, feed or water.

Finally, the Agency proposes to allow registrations to continue for the sapstain control use of sodium penta and the millwork and plywood, and particleboard uses of penta with changes in the terms and conditions of registration. Specifically, for all these uses the Agency will (1) classify these pesticides for restricted use, (2) require all applicators to wear gloves in the treatment plants and to wear neoprene-coated cotton or rubberized protective clothing and respirators when cleaning treatment vats, and (3) require all applicators who apply penta by the spray method to wear gloves and a respirator. Moreover, the Agency will require that prilled and powder formulations of penta and sodium penta be emptied and mixed in closed systems, that all protective clothing and equipment be left at the treatment plant, and will prohibit applicators from eating, drinking, or smoking while applying these pesticides.

The Agency will also restrict the application of these pesticides to wood intended for outdoor and low exposure interior use, and will restrict the application of these pesticides to wood intended for uses that may result in the contamination of animals food, feed, or water.

In addition to these proposed options for reducing risk under FIFRA, the Agency believes it is important to reduce risks to the general population and to specific occupational groups who use treated wood or treated wood products. Under the regulations issued pursuant to FIFRA, the Agency does not currently regulate end-use products, such as treated wood, where no pesticidal claims are made for the treated item itself. Therefore, these options will be proposed through a labeling rulemaking under the Toxic Substances Control Act (TSCA). The intent of the TSCA labeling is to ensure that potentially exposed populations are aware of the appropriate ways to minimize the exposure and risk from wood preservative compounds.

The Agency recognizes that the Consumer Product Safety Commission (CPSC) has some regulatory jurisdiction pertaining to the consumer use of wood treated with pesticides. The CPSC, however, has not issued any pertinent regulations to date. If the CPSC promulgates regulations covering wood treated with pesticides, TCSA will be preempted to the extent that the CPSC takes sufficient actions to protect against the risks of concern. The Agency schedule for completing this TSCA action includes a Notice of Proposed Rulemaking by May 1981, public hearings in August, and final rule by December 1981. This schedule would mesh with the projected date for a final decision under FIFRA (December 1981).

In developing this regulatory position, the Office of Pesticide Programs coordinated with the EPA Office of Solid Waste in the disposal of preservative-treated wood, the EPA Office of Drinking Water, regarding occurrence of wood preservatives in drinking water, and the EPA Office of Toxic Substances, concerning TSCA capabilities in controlling treated wood. Other organizations the Agency consulted were the Occupational Safety and Health Administration (OSHA), regarding their jurisdiction over wood preservatives for worker safety, the CPSC regarding regulation of treated wood, the U.S. Department of Agriculture (USDA), concerning benefits of wood preservatives, and the National Institute of Occupational Safety and Health (NIOSH) about possible epidemiology studies in treatment plants.

Many companies have registered wood preservative products. The companies range in size from very small to Fortune-500 giants. There are from 400 to 600 wood preservative treatment plants, employing about 13,000 workers, and thousands of sawmills and other work situations where wood preservatives may be used. The majority of the treatment plants have fewer than 20 workers, but about 5% of the plants have more than 100 workers. The plant technologies range from fairly primitive to highly sophisticated.

The economic impacts of the proposed modifications for treatment plants using pressure or non-pressure applications are given below. In estimating the costs, the Agency assumes that these industries already provide employees with some protective clothing; therefore, these estimates reflect only the increase in cost to these industries (except for particleboard).

To the wood preserving industry using pressure treatment, the total cost to implement the proposed modifications (protective clothing and equipment, restricted use, closed systems, and arsenic surface residues) for the three wood preservatives would range from $4 million to $5.7 million for the first year and from $3.8 million to $5.4 million for each subsequent year.

To the industry which treats millwork and plywood with penta, the total cost to implement the proposed modifications (protective clothing and equipment, and restricted use) would range from $4.1 million to $4.9 million for the first year and from $4.1 to $4.8 million for each subsequent year. The total cost of implementing the proposed modifications (protective clothing and equipment, closed systems, and restricted use) to the industry that treats wood with sodium penta for sapstain control would range from $9.1 million to $11.7 million for the first year and from $4 million to $5 million for each subsequent year. The total cost to the one plant treating particleboard with penta, assuming that closed systems are needed and that protective clothing is not currently supplied by the plant, is $12,000 to $17,000 for the first year; for each subsequent year a cost ranging from $1,800 to $5,600 for the protective clothing would expected.

The total cost of implementing the proposed modifications (protective clothing and equipment, and restricted use) to the industry treating the groundline of poles with creosote and penta would be $45 thousand to $150 thousand for the first year and from $42 thousand to $160 thousand for each subsequent year. For the home and farm use, the cost of implementing the proposed modifications (protective clothing and equipment, and restricted use) for the certified applicators is expected to range from $3.5 million to $3.6 million for the first year and for each subsequent year; for non-certified home and farm applicators, the cost to each individual will range from insignificant to $25, depending on the protective clothing which must be purchased. The cost impacts for the poles-groundline industry and the certified home and farm application may be vastly overestimated because the Agency has developed its figures based on the assumptions that protective clothing is not currently used.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

PAGE NO.

PART I. INTRODUCTION.............................. 1

A. General Background and Organization of this Position Document.............................. 1

B. Legal Background.............................. 2

  1. The Statute.............................. 2

  2. The RPAR Process.............................. 3

C. Chemical Background.............................. 5

  1. Creosote.............................. 5

    a. Chemical and Physical Characteristics.... 5

    b. Registered Uses and Production........... 7

    c. Tolerances.............................. 7

  2. Inorganic Arsenical Compounds................ 9

    a. Chemical and Physical Characteristics.... 9

    b. Registered Uses and Production........... 11

    c. Tolerances.............................. 12

  3. Pentachlorophenol.............................. 13

    a. Chemical and Physical Characteristics.... 13

    b. Registered Uses and Production........... 17

    c. Tolerances.............................. 18

  4. Alternative Wood Preservative Compounds...... 19

    a. Chemical and Physical Characteristics.... 19

    b. Registered Uses and Production........... 21

    c. Tolerances.............................. 22

PART II. RISK ANALYSES AND ASSESSMENTS.............. 23

A. Purpose and Organization........................ 23

B. Creosote.. 25

1. Analysis of Rebuttal Comments Concerning Mutagenicity................................. 25

a. Basis of Presumption.................... 25

b. Analysis of Specific Rebuttal Comments... 27

c. Summary of Rebuttal Comments Concerning Mutagenic Effects: Conclusion......... 34

2. Analysis of Rebuttal Comments Concerning Oncogenicity................................. 36

a. Basis of Presumption.................... 36

b. Analysis of Specific Rebuttal Comments... 46

c. Summary of Rebuttal Comments Concerning Oncogenicity: Conclusion.............. 56

3. Analysis of Rebuttal Comments Concerning Human Exposure............................. 58

4. Revised Human Exposure Analysis.............. 64

a. Chemistry............................... 64

b. Description of Treatment Process......... 66

c. Revised Human Exposure Analysis for Specific Exposure Situations........... 68

5. Qualitative Risk Assessment for Mutagenicity. 75

6. Qualitative Risk Assessment for Oncogenicity. 85

a. Introduction............................ 85

b. Chemical Composition of Creosote and Creosote/Coal Tar Blends............... 86

c. Toxicology.............................. 87

d. Conclusion.............................. 92

C. Inorganic Arsenical Compounds.................... 95

1. Analysis of Rebuttal Comments Concerning Interconversion of Pentavalent to Trivalent Arsenic......................... 95

a. Basis of Concern......................... 95

b. Analysis of Specific Rebuttal Comments... 97

c. Summary of Rebuttal Comments Concerning Interconversion: Conclusion........... 102

2. Analysis of Rebuttal Comments Concerning Oncogenicity................................ 103

a. Basis of Presumption..................... 103

b. Analysis of Specific Rebuttal Comments... 105

c. Summary of Rebuttal Comments Concerning Onogenicity: Conclusion................ 111

3. Analysis of Rebuttal Comments Concerning Mutagenicity................................ 111

a. Basis of Presumption..................... 111

b. Analysis of Specific Rebuttal Comments... 118

c. Summary of Rebuttal Comments Concerning Mutagenic Effects: Conclusion......... 126

4. Analysis of Rebuttal Comments Concerning Fetotoxic and Teratogenic Effects.......... 127

a. Basis of Presumption..................... 127

b. Analysis of Specific Rebuttal Comments... 145

c. Summary of Rebuttal Comments Concerning Fetotoxic and Teratogenic Effects: Conclusion............................ 158

5. Other Health and Environmental Concerns: Delayed Neurotoxicity...................... 160

a. Basis of Concern......................... 160

b. Analysis of Specific Rebuttal Comments... 166

c. Summary of Rebuttal Comments Concerning Neurotoxicity Effects: Conclusion..... 168

6. Analysis of Rebuttal Comments Concerning Human Exposure 168

a. Basis of Analysis 168

b. Analysis of Specific Rebuttal Comments... 170

c. Summary of Rebuttal Comments and Revised Assumptions 193

7. Revised Human Exposure Analysis.............. 195

a. Introduction............................. 195

b. Summary of Breathing Rate Assumptions.... 196

c. Discussion of Data Range Assumptions..... 196

d. Revised Human Exposure Analysis for Specific Exposure Situations........... 203

e. Summary.................................. 211

8. Quantitative and Qualitative Risk Assessments.................................... 214

a. Oncogenic Effects....................... 214

b. Mutagenic Effects....................... 218

c. Teratogenic and Fetotoxic Effects........ 232

D. Pentachlorophenol

1. Analysis of Rebuttal Comments Concerning Fetotoxic and Reproductive Effects......... 247

a. Basis of Presumption.................... 247

b. Analysis of Specific Rebuttal Comments... 253

c. Summary of Rebuttal Comments: Conclusion 261

2. Analysis of Rebuttal Comments About Exposure; Revised Exposure Analysis................. 263

a. Basis of Analysis....................... 263

b. Analysis of Specific Rebuttal Comments... 264

3. Revised Human Exposure Analysis.............. 296

a. Assumptions and Methods................. 296

b. Penta Concentrations Measured in Air..... 299

c. Penta Residues in Human Urine and Serum.. 309

d. Revised Human Exposure Analysis for Specific Exposure Situations........... 313

e. Summary of Revised Human Non-Dietary Exposure Analysis...................... 336

f. Dietary Exposure........................ 336

4. Pentachlorophenol's Potential Oncogenicity... 344

a. Introduction............................ 344

b. Hexachlorodibenzo-p-dioxin............... 345

c. Hexachlorobenzene........................ 345

5. Quantitative and Qualitative Risk Assessments................................ 347

a. Fetotoxic, Teratogenic, and Reproductive Effects............................... 347

b. Oncogenicity............................. 356

E. Alternatives.................................. 367

1. Introduction.............................. 367

2. Acid Copper Chromate (ACC) and Chromated Zinc Chloride (CZC) as Chromium............ 368

3. Bis(tributyltin) Oxide (TBTO)................ 369

a. Acute Toxicology........................ 369

b. Chronic Toxicology....................... 370

4. Copper-8-Quinolinolate (Cu-8)................ 371

a. Acute Toxicology........................ 371

b. Chronic Toxicology....................... 372

5. Copper Naphthenate.......................... 372

a. Acute Toxicology........................ 372

b. Chronic Toxicology....................... 373

6. Zinc Naphthenate............................ 374

a. Acute Toxicology........................ 374

b. Chronic Toxicology........................ 374

7. Trichlorophenol and Tetrachlorophenol........ 375

a. Introduction............................... 375

b. 2,4,5 Trichlorophenol...................... 375

c. 2,4,6 Trichlorophenol...................... 376

d. 2,3,4,6 Tetrachlorophenol.................. 376

8. Summary...................................... 376

PART III. BENEFIT ANALYSIS...................... 379

A. Introduction................................. 379

B. Pressure Treatments.......................... 380

1. Profile of the Wood Treatment Industry....... 380

a. Introduction............................... 380

b. Usage of Wood Preservatives................ 381

c. Employment and Revenue..................... 393

2. Comparative Costs of Wood Preservatives Compounds, Their Future Availability and Price, and the Projected Service Life of Treated Wood...................................... 394

a. Introduction............................... 394

b. Comparative Costs of Wood Preservative and Service Life of Treated Wood....... 395

c. Future Availability and Price of Creosote 410

d. Future Availability and Price of Inorganic Arsenicals.................... 411

e. Future Availability and Price of Penta... 413

3. Capital Requirements for Alternative Treatments................................... 413

4. Methods and Assumptions...................... 417

5. Benefit Analysis by Use Category for Pressure Treatments................................... 421

a. Railroad Ties.............................. 421

b. Lumber, Timber and Plywood............... 427

c. Pilings.................................. 440

d. Posts.................................... 454

e. Crossarms................................ 462

f. Poles.................................... 467

C. Non-Pressure Treatments.......................... 486

1. Profile of the Wood Treatment Industry and Applicators for Non-Pressure Treatments.... 486

a. Poles-Groundline......................... 486

b. Home and Farm............................ 487

c. Sapstain Control......................... 487

d. Millwork and Plywood..................... 487

e. Particleboard............................ 489

2. Benefit Analysis by Use Category for Non-Pressure Treatments..................... 489

a. Poles-Groundline......................... 489

b. Home and Farm............................ 494

c. Sapstain Control......................... 512

d. Millwork and Plywood..................... 523

e. Particleboard............................ 528

D. Summary of Wood Preservatives Economic Impacts.. 532

1. Introduction................................. 532

2. Pressure Treatments.......................... 532

3. Non-Pressure Treatments...................... 549

PART IV. DEVELOMENT OF REGULATORY OPTIONS........... 553

A. Introduction..................................... 553

B. Basis and Rationale for Developing Options and Modifications.................................... 553

C. Discussion of Option 2, Modifications to the Terms and Conditions of Registration.................. 555

a. Require Protective Clothing: Gloves.... 556

b. Require Protective Clothing: Coveralls. 557

c. Require Protective Clothing: Neoprene Suit and Respirators.................... 558

d. Require Protective Clothing: Dust Mask. 559

e. Require Special Laundering and Care of Protective Clothing..................... 559

f. Prohibit Eating, Drinking and Smoking During Application...................... 560

g. Confine Emptying Bags and Mixing of Powder and Prilled Formulations to closed Systems................................ 561

h. Classify for Restricted Use............. 562

i. Restrict Application of Wood Preservatives to Outdoors and the Application of Wood Preservatives to Wood Destined for Interior Uses.......................... 563

j. Prohibit Uses Likely to Result in Direct Exposure to Domestic Animals or Livestock or in the Contamination of Food, Feed, or Potable Water.......................... 563

k. Require Special Disposal of Treated Wood.................................. 564

l. Reduce Contaminants in Penta............ 566

D. Other Relevant Statutory Measures................. 567

1. Occupational Safety and Health Act............ 567

2. Toxic Substances Control Act.................. 568

3. Consumer Product Safety Act................... 570

4. Resource Conservation and Recovery Act........ 571

PART V. REVIEW OF THE IMPACTS OF REGULATORY OPTIONS AND MODIFICATIONS......................... 573

A. Introduction.................................... 573

B. Use Categories: Pesticides Applied at Pressure and Non-Pressure Treatment Plants.................... 575

1. Summary of Risks........................... 576

a. Creosote.................................. 578

b. Inorganic Arsenical Compounds............ 581

c. Penta..................................... 586

2. Summary of Benefits........................ 590

a. Introduction.............................. 592

b. Pressure Treatment Plant Uses............ 593

c. Non-pressure Treatment Plant Uses........ 608

3. Risk/Benefit Analysis...................... 612

a. Consideration of Regulatory Options...... 612

b. Risk/Benefit Impacts of Modifications Under Consideration for Treatment Plants....... 613

4. Selection of Regulatory Options and Modifications for Treatment Plants............ 633

a. Creosote.................................. 635

b. Inorganic Arsenicals...................... 636

c. Penta..................................... 637

d. Specific Options Selected................ 638

C. Use Categories: Pesticides Applied Outside of Treatment Plants................................. 663

1. Summary of Risks........................... 663

a. Poles-Groundline.......................... 663

b. Home and Farm............................. 664

c. Brush-on Applications of the Inorganic Arsenicals............................... 666

2. Summary of Benefits........................ 666

a. Poles-Groundline.......................... 666

b. Home and Farm............................. 668

c. Brush-on Applications of the Inorganic Arsenicals............................... 670

3. Risk/Benefit Analysis........................ 670

a. Consideration of Regulatory Options...... 670

b. Risk/Beknefit Impacts of Modifications Under Consideration for Poles-Ground, Home and Farm, and Brush-on Applications of the Inorganic Arsenicals.............. 671

4. Selected Modifications for Poles-Groundline (Creosote and Penta), Home and Farm (Creosote and Penta), Brush-on Applications of the Inorganic Arsenicals.......................... 679

a. Poles-Groundline......................... 680

b. Home and Farm............................ 682

c. Brush-on Applications of the Inorganic Arsenicals..................... 684

D. End-Uses of Treated Wood......................... 685

1. Summary of Risks............................. 686

a. Creosote................................. 686

b. Inorganic Arsenicals..................... 687

c. Penta.................................... 688

2. Summary of Benefits.......................... 690

3. Risk/Benefit Analysis........................ 691

a. Consideration of Regulatory Options...... 691

b. Possible Modifications Under FIFRA....... 692

c. Possible Modifications Under TSCA........ 696

E. Summary of Proposed Regulatory Action Under FIFRA... 703

F. Summary of Projected Regulatory Measures Under TSCA.. 719

Appendix 1A-C: Rebuttal Comments Received

Appendix 2: Concepts that Were Considered as Possible Regulatory Options for the Wood Preservative Pesticides

Bibliography

I. INTRODUCTION

A. General Background and Organization of this Position Document

The Federal Insecticide, Fungicide, and Rodenticide Act as amended (FIFRA) and its regulations require the Environmental Protection Agency (EPA) to review the risks and benefits of the uses of pesticides. On October 18, 1978, EPA issued Notices of Rebuttable Presumption Against Registration and Continued Registration (RPAR) of pesticide products containing coal tar, creosote, and coal tar neutral oils, of those containing the inorganic arsenical compounds, and of those containing pentachlorophenol and its salts. The presumption against coal tar, creosote, and coal tar neutral oils was based on validated studies showing that these compounds are oncogenic and mutagenic; the presumption against the inorganic arsenical compounds was based on studies showing they are oncogenic, mutagenic, and fetotoxic; the presumption against pentachlorophenol (penta) was based on studies showing it is teratogenic and fetotoxic. The Position Document 1 (PD-1) issued with the Notice of Rebuttable Presumption describes these studies in detail. Since the publication of PD-1, other validated studies have shown that some contaminants of penta are oncogenic.

This Position Document 2/3 (PD-2/3) addresses the risks and benefits of the wood preservative uses of creosote, coal tar, and coal tar neutral oils, the inorganic arsenical compounds, and pentachlorophenol. The other uses of these pesticides will be considered in future position documents. This document contains five parts. Part I is this introductory section. Part II evaluates the potential risks of these wood preservatives. It includes descriptions and evaluations of the risk evidence, exposure data, rebuttal submissions, and the Agency's present risk assessment. Part III estimates and summarizes the economic benefits of these wood preservatives for each use category and describes the assumptions and limits of these estimates. Part IV describes the range of possible regulatory options and modifications to reduce the risks of these pesticides, and explains the Agency's selection of some of these options for further consideration. Part V evaluates the specific impact on the risks, benefits, and other effects which would occur if each applicable option and modification for each use category were adopted and presents the options and modifications selected by the Agency.

B. Legal Background

1. The Statute

The FIFRA (7 U.S.C. S136 et seq.) regulates all pesticide products. Under Section 12(a)(1)(A) of FIFRA all pesticides must be registered before they may be sold or distributed. Before the Administrator may register a pesticide, however, he must determine that its use will not result in "unreasonable adverse effects on the environment," which is defined by Section

2(bb) of FIFRA to mean "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide." In other words, any decision about pesticide registration or continued registration must take into account both the risks and the benefits of the use of the pesticide.

Section 6(b) of FIFRA authorizes the Administrator to issue a notice of intent to cancel the registration of a pesticide or to change its classification if it appears to him that the pesticide or its labeling "does not comply with the provisions of [FIFRA] or, when used in accordance with widespread and commonly recognized practice, generally causes unreasonable adverse effects on the environment." Thus, the Administrator may cancel the registration of a pesticide whenever he determines that it no longer satisfies the statutory standard for registration; that standard requires, among other things, that the pesticide not cause "unreasonable adverse effects on the environment" [FIFRA Section 3(c)(5)(C)]. He may also cancel the registration of a pesticide if its labeling does not comply with the misbranding provisions of FIFRA which require the labeling to contain language "adequate to protect health and the environment" [FIFRA Section 2(q)].

2. The RPAR Process

The Agency has designed a process, known as the Rebuttable Presumption Against Registration (RPAR) process, to gather risk and benefit information about pesticides which appear to pose unreasonable risks to health or to the environment. This process, designed to allow an open, balanced decision with participation by all interested groups, is set forth in 40 CFR 162.11. These regulations describe various risk criteria, and provide that an RPAR shall arise if the Agency determines that any of the risk criteria have been met. Once a notice of rebuttable presumption has been published, registrants, applicants and interested persons may submit evidence in rebuttal or in support of the presumption. All parties may also submit evidence on the economic, social, and environmental benefits of any use of the pesticide. If the presumptions of risk are not rebutted, the benefits evidence submitted to or gathered by the Agency must be evaluated and considered with the risk information. The Agency analyzes various risk reduction methods and their costs. The Agency then determines if a pesticide's use may be regulated so that its risks are outweighed by its benefits. If a balance between risks and benefits cannot be reached for a specific use, the registration for that use must be cancelled or otherwise restricted, or, in the case of a new application, denied.

C. Chemical Background

1. Creosote

a. Chemical and Physical Characteristics

Creosote and coal tar are extremely complex mixtures containing hundreds of identifiable constituents. These mixtures are produced by the high temperature carbonization of coal, a process referred to as coking. They vary in composition, depending on the temperature of coking and the source of coal used (Nestler, 1974). However, unless otherwise specified or explained, this document will use the term "creosote" to refer to all three of the wood preservatives derived from coal tar, that is, coal tar, creosote, and coal tar neutral oil. Products similar to coal tar-derived creosote, which are also called creosote, may be distilled from sources other than coal, but these products are very different in chemical composition, and therefore this document refers only to those products distilled from coal tar.

Coal tar is produced by the carbonization (coking) of coal. Theoretically, there may be as many as ten thousand compounds in coal tar, although most of these compounds are present only in trace amounts (NIOSH, 1977). Over three hundred compounds have been positively identified in coal tar. The chemical reactions in the process are not well understood. It is known, however, that the duration and temperature of the process affect the mixture of the constituents formed; longer durations and higher temperatures favor the formation of more highly condensed aromatic compounds such as polynuclear aromatic hydrocarbons (PAH's). Low temperature carbonization yields approximately twice as much oil and tar as high temperature carbonization.

Coal tar is a black, viscous liquid that has a naphthalene-like odor and a sharp burning taste. It combustible and has a specific gravity of 1.18-1.23 (60/60°F). It is soluble in benzene, carbon disulfide, and chloroform, partially soluble in alcohol, acetone and methanol, and only slightly soluble in water (Hawley, 1977).

The American Wood Preservers Association (AWPA) defines creosote as a distillate derived from coal tar which consists principally of liquid and solid aromatic hydrocarbons, although some tar acids and bases are also present. It is heavier than water and has a continuous boiling range from about 200°C to about 450°C (AWPA, 1976; Nestler, 1974). The AWPA promulgates standards for creosote and blended creosote/coal tar solutions (e.g., 60/40, 70/30, and 80/20) for use as wood preservatives based on water content, benzene-soluble material, specific gravity, and distillation range (see PD-1, Appendices A and B).

Smale (1977) states that coal tar neutral oils are generally defined as a mixture of naphthalene, fluorene, anthracene, and other neutral hydrocarbons. Neutral hydrocarbons are those coal tar hydrocarbons other than coal tar acids (such as phenol, cresols, and cresylic acids) and coal tar bases (such as pyridines, quinolines, and acridines).

b. Registered Uses and Production

By far the largest pesticidal use (98%) of creosote is as a wood preservative. Creosote is nearly always (>90%) applied by pressure-treating methods (American Wood Preservers Institute, 1977). In 1972, of the 1,150 million pounds of creosote used in the United States, 972 million pounds were used as wood preservatives (Von Rumker _et al._, 1975). In 1975, about 843 million pounds (96,266,000 gallons of creosote) were used as a wood preservative (Fuller _et al._, 1977). Pesticide production data reported to the Environmental Protection Agency under Section 7 of FIFRA indicated that 366,839,110 pounds of creosote, 34,847,384 pounds of coal tar, and 2,019,951 pounds of coal tar neutral oils were formulated or blended for pesticidal use in 1975. The quantity of creosote and creosote solutions consumed by the wood preserving industry in 1978 was 34,100,000 gallons of creosote, 66,400,000 gallons of creosote-coal tar solutions and 30,200,000 gallons of creosote-petroleum (Maloney and Pagliai, 1979).

c. Tolerances

This Agency has established no tolerances or exemptions from tolerances, and the U.S. Food and Drug Administration (FDA) has established no action levels for creosote in or on raw agricultural commodities. Under the provisions of 21 CFR, the FDA has not established an indirect food additive regulation* for creosote where it may be used safely as a wood preservative for holding, transporting, or packaging raw agriculture products.

The absence of tolerances and exemptions from tolerances for creosote is of concern to the Agency because some use patterns of creosote may result in creosote residues in food or feed.

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* According to CFR 21, Part 170, Section 170.3, "food additive" includes all substances in which the intended use of which results, or may reasonably be expected to result, directly or indirectly, either in their becoming a component of food, or otherwise affecting the characteristics of food. Material used in the production of containers and packages is subject to the definition if it may reasonably be expected to become a component, or to directly or indirectly affect the characteristics of food packed in the container. The general provisions applicable to "indirect food additives" (Part 174, Section 174.5) are regulations prescribing conditions under which food additive substances may be safely used and predicate usage under conditions of good manufacturing practice. The quantity of any food additive substance that may be added to food as a result of use in articles that contact food shall not exceed, where no limits are specified, that which results from use of the substance in an amount not more than reasonably required to accomplish the intended physical or technical effect in the food-contact article; shall not exceed any prescribed limitations; and shall not be intended to accomplish any physical or technical effect in the food itself.

2. Inorganic Arsenical Compounds

a. Chemical and Physical Characteristics

Because arsenic has multiple valence states, the inorganic arsenical compounds have distinctly different physical and chemical properties. Arsenic pentoxide, sodium arsenate, arsenic acid, and sodium pyroarsenate are pentavalent arsenical compounds; ammonium arsenite and arsenic trioxide are trivalent arsenical compounds. These are the compounds used in the formulation of inorganic arsenical wood preservatives. (Another compound of concern is arsine, a toxic gas which may be produced by burning arsenical-treated wood or by other processes.)

i. Arsenic Pentoxide

Arsenic pentoxide is a white, amorphous solid. Its chemical formula is As_2O_5, its molecular weight is 229.82, its density is 4.3, and it decomposes at 315°C. It is very soluble in water, 1500 g/liter (Oak Ridge, 1976).

ii. Sodium Arsenate

Sodium arsenate's chemical formula is Na_2HAsO_4, its molecular weight is 185.91, and its density is 1.9. It is a grey-white powder and is very soluble in water (Oak Ridge, 1976).

iii. Arsenic Acid

Arsenic acid is the common name for orthoarsenic acid. Its chemical formula is H_3AsO_4, its molecular weight is 141.93, and its density is 2.0 to 2.5 (Meister, 1977). It occurs as white, translucent crystals at 20°C. Its melting point is 35.5°C and the boiling point is 160°C in the anhydrous state. The solubility of arsenic acid in water is 167 g/liter (Oak Ridge, 1976).

iv. Sodium Pyroarsenate

Sodium pyroarsenate's chemical formula is $Na_4As_2O_7$, its molecular weight is 353.79, and its density is 2.2. It occurs as white crystals and decomposes at 1,000°C. Its melting point is 850°C, and it is very soluble in water (Weast, 1977).

v. Ammonium Arsenite

The chemical formula of ammonium arsenite is NH_4AsO_2. Its molecular weight is 125, and its density is 1.3. It forms colorless, hygroscopic rhombic prisms. It is very soluble in cold water and decomposes in hot water (Weast, 1977).

vi. Arsenic Trioxide

Arsenic trioxide is the common name for arsenious (or arsenous) oxide. Refined arsenic trioxide is known as white arsenic. Arsenic trioxide occurs as an amorphous white powder or as a vitreous solid. Its chemical formula is As_2O_3 (also As_4O_6), its molecular weight is 197.8, and its density is 3.7. It boils at 465°C and sublimes at 193°C. Its solubility in water is 20.6 g/liter (Oak Ridge, 1976).

b. Registered Uses and Production

There are three inorganic arsenical wood preservatives of commercial importance: chromated copper arsenate (CCA), ammoniacal copper arsenate (ACA), and fluor chrome arsenate phenol (FCAP). These three wood preservatives are various mixtures made, in part, from ammonium arsenic pentoxide, or sodium arsenate, or sodium pyroarsenate.

In industrial situations, concentrates of the inorganic arsenical formulations are delivered as powders, liquid concentrates, or pastes. These concentrates are dumped or otherwise metered and mixed with water to form dilute treating solutions of 0.75

to 6.0%, depending on the intended end-use of the treated wood. Although the majority of wood is treated in closed cylinders under pressure, sometimes the preservatives are painted on wood or the wood is dipped or soaked in the solutions.

Ammonium arsenite is formulated with other ingredients (the final concentration of ammonium arsenite is 7.7%) for use in pressurized wood treatment systems. Arsenic pentoxide and arsenic trioxide are also formulated with other ingredients (final concentrations of arsenic pentoxide or arsenic trioxide are either 1.5% or 37.0%) for pressure treatment. Sodium pyroarsenate is formulated with other ingredients (final concentration = 6.2%) for pressure treatment. Sodium arsenate, which is also used as an insecticide, is available as a 43% dust, a 2% solution, and in 14.0% to 43.5% formulations with other ingredients for pressure use (Meister, 1977; EPA, 1975).

The total volume of inorganic arsenical wood preservatives has increased threefold, from 8,952,000 pounds in 1967 to 27,300,000 pounds in 1977. Nearly 20% of treated wood products are treated with inorganic arsenical compounds (AWPA, 1978).

c. Tolerances

This Agency has not established tolerances or exemptions from tolerances, and the FDA has not established action levels for arsenic residues in or on raw agricultural commodities resulting from wood uses of arsenic pentoxide, sodium arsenate, arsenic acid, sodium pyroarsenate, ammonium arsenite and arsenic trioxide, or inorganic arsenical wood preservative formulations. Under the provisions of 21 CFR, the FDA has not established an indirect food additive regulation* for these wood preservative compounds or their formulations.

The absence of tolerances and exemptions from tolerances for the inorganic arsenical compounds is of concern to the Agency because some use patterns of these compounds may result in residues in food or feed.

3. Pentachlorophenol

a. Chemical and Physical Characteristics

Pentachlorophenol is commonly called "penta." It is a buff colored crystal which is produced in the United States by chlorination of molten phenol in the presence of a catalyst. The major commercial forms of penta are the unmodified phenol and the sodium salt. Figure 1 shows the structural formulae of these forms of penta, while Table I-1 contains the chemical and physical properties of these compounds. Two other forms, not used as wood preservatives, are the potassium salt and the lauric acid ester.

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* See footnote on page 8.

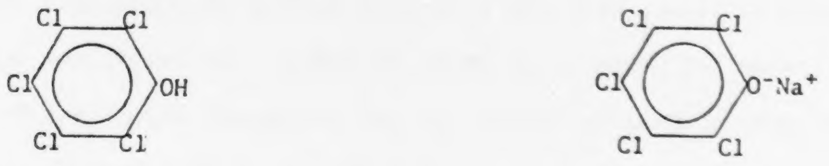
Table 1-1

Physical Properties of Pentachlorophenol and Sodium Pentachlorophenate

Name	Pentachlorophenol	Sodium Pentachlorophenol
Formula	C_6Cl_5OH	$C_6Cl_5ONa.H_2O$
Molecular Weight	266.4	306.3
Specific Gravity	1.9	2.0
Density	1.987	-
Vapor Pressure	0.00015 (25°C)	-
Solubility, g/100 g, 25°C		
Water	<0.01	33
Acetone	50	35
Benzene	15	-
Diaetone Alcohol	190	45
Ethanol (95%)	120	65
Methanol	180	25
Isopropanol	85	30
Ethylene glycol	11	40

FIGURE 1

Structure of Penta and Its Sodium Salt

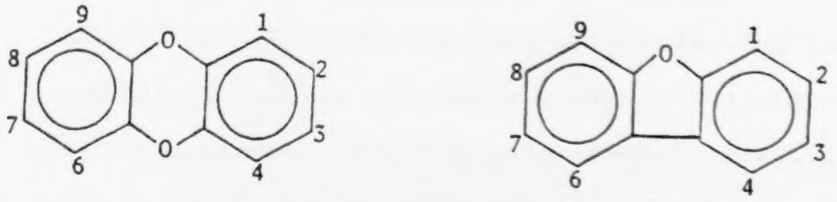

Cl
Cl
Cl
OH
Cl
Cl
Cl
Cl
Cl
O⁻Na⁺
Cl
Cl

Pentachlorophenol

Sodium Pentachlorophenate

FIGURE 2

Structure of Dioxin and Furan


9
O
1
8
2
7
3
O
6
4
9
O
1
8
2
7
3
6
4

Dibenzo-p-dioxin

Dibenzofuran

Industrial production of penta is a two-stage process. In the first stage, phenol is chlorinated at 105°C to yield isomers of tri- and tetrachlorophenols. In the second stage, the temperature is gradually increased to 130°C to keep the reaction mixture molten, and the tri- and tetrachlorophenols are further chlorinated to form pentachlorophenol. However, not all of these precursor compounds react in the process; some of the tetrachlorophenols survive and remain with the penta through later processing. Technical grade penta, therefore, contains from 4 to 12% tetrachlorophenols; in fact, one of the three possible tetrachlorophenol isomers, 2,3,4,6-tetrachlorophenol, is listed as an active ingredient in some penta products.

Dioxin and furan contaminants also form in the commercial production of penta. The higher temperatures of the second stage of penta production are favorable to the condensation of the tri- and tetrachlorophenols to form hexa-, hepta-, and octachlorodibenzo-p-dioxins (dioxins) and various chlorinated dibenzofurans (furans). Figure 2 shows the structural formulae of the basic molecules of these contaminants. Substitution of chlorine atoms at one or more of the numbered positions produces a member of the chlorinated dibenzo-p-dioxin (dioxin) or chlorinated dibenzofuran (furan) chemical families.

Buser and Bosshardt (1976) report that the forms of dioxins most prevalent in commercial penta are hexa-, hepta-, and octachlorodibenzo-p-dioxins (HxCDD, HpCDD, and OCDD, respectively). A small amount of tetrachlorodibenzo-p-dioxin (TCDD) has also been found in penta (Buser, 1976), although this proved not to be the extremely toxic 2,3,7,8-isomer. The furans found in penta are the tetra-, penta-, hexa-, hepta-, and octachlorodibenzofurans (Buser and Bosshardt, 1976).

b. Registered Uses and Production

Many products containing penta and its sodium salt are registered as wood preservatives. They are among the most versatile pesticides now in use, due to their efficacy against a wide range of pests (bacteria, yeast, slime molds, algae, fungi, plants, insects, snails), and to their solubility in both organic solvents (penta) and water (sodium penta).

As of 1977, about 50 million pounds of penta were produced annually in the United States; production was expected to increase to 80 million pounds annually in the near future (Josephson, 1977). In general, about 80% of all penta produced is used for wood preservation. However, this use did not increase in 1978, when the U.S. wood preservative industry used only about 29,900,000 lbs. of penta (Maloney and Pagliai, 1979). Most of the remaining penta is used in register fungicide products applied to wide variety of industrial products including leather, burlap, masonry, cordage, paint, pulp and paper mills, and cooling towers.

The absence of tolerances and exemptions from tolerances for penta is of concern to the Agency because some other use patterns of penta may result in residues in food or feed.

c. Tolerances

This Agency has established no tolerances or exemptions from tolerances, and FDA has not established action levels for pentachlorophenol in or on raw agricultural commodities. The FDA has several regulations permitting the use of penta in wood and non-wood packaging materials as an indirect food additive*.

One of these regulations (21 CFR, Part 178.3800) indicates that penta and its sodium salt may be applied safely to wooden articles intended for use in packaging, transporting, or holding raw agricultural products. The regulation specifies that penta residues, which occur when penta is applied as a wood preservative, are not to exceed 50 parts per million (ppm), calculated as penta, in the treated wood.

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* See footnote on page 8.

4. Alternative Wood Preservative Compounds

a. Chemical and Physical Characteristics

i. Bis(tri-n-butyltin) oxide

Bis(tri-n-butyltin) oxide is a colorless to light yellow liquid. Its chemical formula is $C_{24}H_{54}OSn_2$, its molecular weight is 594, and its specific gravity is 1.17 at 25°C (Hawley, 1977). Bis(tri-n-butyltin) oxide's boiling point is 180°C at 2mm Hg and its freezing point is below -45°C, with negligible vapor pressure. Its solubility in water is about 20 ppm at room temperature and it is miscible with most organic solvents. It is made through the Grignard reaction with stannic oxide to give tributyltin chloride, which is then hydrolyzed to the oxide (Martin, 1972).

ii. Copper-8-quinolinolate

Copper-8-quinolinolate is a yellow-green, nonhygroscopic, odorless powder. Its molecular weight is 351.86 (NIOSH, 1977), and its chemical formula is $Cu(C_9H_6ON)_2$. It is soluble in water and most organic solvents. Copper-8-quinolinolate is derived from 8-quinolinol and a copper salt, such as copper acetate (Hawley, 1977). Solubilized copper-8-quinolinolate is the product formed by heating copper-8-quinolinolate with certain organic acids (naphthenic, lactic, or stearic, among others) or their salts. In these products, the copper-8-quinolinolate does not settle out on standing, even after dilution with various solvents.

iii. Copper naphthenate

Copper naphthenate is a green-blue solid. It is practically insoluble in water, moderately soluble in petroleum oils, and soluble in most organic solvents. Copper naphthenate is made by the interaction of soluble copper salts (cupric sulfate) with naphthenate, the latter being carboxylic acids derived from crude petroleum oils (Hawley, 1977; Martin, 1972).

iv. Zinc naphthenate

Zinc naphthenate is an amber, viscous, basic liquid (8-10% Zn) or basic solid (16% Zn). Its chemical formula is $Zn(C_6H_5COO)_2$ and it is very soluble in acetone. Zinc naphthenate is made by fusing zinc oxide or hydroxide and naphthenic acids, or by precipitating from a mixture of soluble salts and sodium naphthenate (Hawley, 1977).

v. Acid copper chromate

Acid copper chromate is essentially a mixture of copper sulfate and sodium dichromate with some addition of chromic acid. The solutions which are used as wood preservatives have a pH range from 2.0 to 3.9 (Fuller, 1977).

vi. Chromated zinc chloride

Chromated zinc chloride is a mixture of zinc chloride and sodium dichromate. The solutions which are used for wood preservation have a pH range from 2.8 to 4.0 (Fuller, 1977).

vii. Sodium tetrachlorophenate

Sodium tetrachlorophenate's chemical formula is $C_6HCl_4ONaH_2O$. It occurs as buff to light brown colored flakes. Its bulk density is 26 to 29 lbs/ft^3 and its pH in a saturated water solution is 9.0 to 13.0. It is soluble in water, methanol, and acetone (Hawley, 1977).

viii. Tetrachlorophenol

Tetrachlorophenol's chemical formula is C_6HCl_4OH and its molecular weight is 231.88. It occurs as brown flakes that melt from 69 to 70°C. Tetrachlorophenol is soluble in acetone, benzene, ether, and alcohol (Hawley, 1977).

b. Registered Uses and Production

All the alternatives are registered as wood preservatives, but some have other uses. Bis(tri-n-butyltin) oxide is used as a fungicide and bactericide, especially in underwater and antifouling paints. Copper-8-quinolinolate is used as a fungicide and for mildew-proofing fabrics. Copper naphthenate is used as a canvas and rope preservative. Zinc naphthenate is used as a dryer and wetting agent in paints, varnishes, and resins, as well as an insecticide and mildewcide. Sodium tetrachlorophenol is used as an industrial preservative (Hawley, 1977).

c. Tolerances

This Agency has established no tolerances, or exemptions from tolerances and FDA has established no action levels for residues resulting from wood uses of bis(tri-n-butyltin) oxide, copper-8-quinolinolate, copper naphthenate, zinc naphthenate, acid copper chromate, chromated zinc chloride, sodium tetrachlorophenate and tetrachlorophenol, or for their wood preservative formulations in or on raw agricultural commodities. Only copper-8-quinolinolate has an indirect food additive regulation established by the FDA under the provisions of 21 CFR, Part 178.3800*.

This regulation states that copper-8-quinolinolate may be safely used for treating wood which is used for holding, transporting, or packaging raw agricultural products. The regulation specifies that the preservative be applied in amounts not to exceed those necessary to accomplish the technical effect of protecting the wood.

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* See footnote on page 8.

II. RISK ANALYSES AND ASSESSMENTS

A. Purposes and Organization

This Part has three purposes. The first is to state the scientific bases of the Agency's concern about the possible risks of the wood preservatives. The second is to analyze comments by the pesticide registrants and other concerned parties about these presumed risks. The third is to assess the risks of the wood preservatives in light of the original concerns and the rebuttal comments.

Risk has two components; the toxic effect (or effects) of the pesticide, and exposure to the pesticide sufficient to cause the toxic effect(s). The toxic effects of concern were first described in PD-1 as the basis for the rebuttable presumption.

For creosote, the rebuttable presumption against registration was issued on the basis of oncogenicity and mutagenicity. For the inorganic arsenicals, the basis of the presumption was oncogenicity, mutagenicity, and teratogenicity; two other issues of concern interconversion and neurotoxicity, were also presented. Although not a basis for the presumption itself, interconversion will be discussed here because it was a major factor supporting the presumptions in PD-1. Neurotoxicity will be discussed because it is still presents a potential concern. For pentachlorophenol, the basis for the presumption was fetotoxicity/teratogenicity.

Since publication of PD-1, new information has indicated that some of the contaminants of penta are oncogenic. Therefore, the rebuttable presumption against penta is now based on oncogenicity as well as fetotoxicity/teratogenicity. This Part describes the scientific basis for this new concern and summarizes the information which formed the basis of the orginal presumption.

Part II is divided into a section for each wood preservative, creosote, the inorganic arsenicals, and penta, in addition to asection which discusses the alternative wood preservatives. Each of the first three sections contains a summary of the basis of the risk presumption (based on PD-1, and new information, where available), a summary of the rebuttal comments on the risk presumption*, and the Agency's decision as to whether the presumption has been rebutted. In addition to the discussion of risks, each section also includes a discussion of exposure to the wood preservative and of rebutters' comments regarding this exposure. Finally, each of the first three sections contains the Agency's assessment of each risk, in light of the Agency's revised position on exposure and risk. The fourth section briefly describes the possible risks of the alternative wood preservatives.

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* After each heading in the rebuttal sections numerical reference numbers are given in parentheses. These reference numbers identify the specific rebutters responsible for the comments; the reference list is given in Appendix 1 of this document.

B. Creosote

1. Analysis of Rebuttal Comments Concerning Mutagenicity

a. Basis of Presumption

In the studies summarized in PD-1, mutagenic effects of creosote and coal tar/creosote were studied in Salmonella typhimurium strains and in L5178Y mouse lymphoma cells. In both cases, these chemicals, upon metabolic activation, produced dose-related increases in mutagenic activity.

i. Simmon and Poole (1978)

This microbiological mutagenic assay was conducted on creosote and coal tar/creosote (4:6) using Salmonella typhimurium (strains TA 1535, TA 1537, TA 98, and TA 100) and Escherichia coli WP2 as mutagenicity detectors both with and without metabolic activation by Aroclor 1254-induced rat liver homogenate. The doses tested ranged from 5 to 5,000 ug/plate. The TA 1537 and TA 98 strains are sensitive to frameshift mutations; WP2, TA 1535, and TA 100 are sensitive to base-pair substitutions; and TA 100 is also sensitive to some frameshift mutations. Both creosote and coal tar/creosote produced positive mutagenic responses, which were about twice those of the negative controls, in S. typhimurium strains TA 1537 (at 10ug/plate), TA 98 (at 5 ug/plate), and TA 100 (at 50 ug/plate). These responses occurred only when the two chemicals were metabolically activated by rodent liver preparations. The S. typhimurium TA 1535 and E. coli WP2 strains did not produce a positive mutagenic response either with or without metabolic activation. The results of Simmon and Poole indicate that the mutagenic mode of action of creosote and coal tar/creosote is frameshift mutation.

ii. Mitchell and Tajiri (1978)

This study was an in vitro mammalian mutagenesis assay. Mouse lymphoma cells (L5178Y), heterozygous at the thymidine kinase locus (TK+/-), were used both with and without by Aroclor 1254-induced rat liver homogenate (S-9 fraction) for activation. The purpose of these tests was to determine the mutagenic activity of creosote and coal tar/creosote on the forward mutation frequency of the TK locus from heterozygous (TK+/-) to homozygous (TK-/-). Ethyl methane sulfonate was used as a positive control in the creosote experiments, and dimethylnitrosamine was the positive control in the coal tar/creosote experiments. For each concentration of test chemical, the mutation frequency results were calculated as the ratio of the number of mutant cells to the total number of surviving cells. The induced mutation frequencies for the tested compound are obtained by subtracting the negative control's average mutation frequency from the treated sample's mutation frequency.

Creosote and coal tar/creosote had similar effects on the forward mutation frequency at the TK locus of the L5178Y mouse cells, both with and without metabolic activation. Dose-related increases in mutation frequencies were reported for both test chemicals following metabolic activation. However, without metabolic activation, the mutation frequency in the creosote testswas reported to be weakly positive at the highest concentration, whereas the experiments with coal tar/creosote resulted in significant increases in the frequency of mutations at the two highest concentrations.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: Reliability of the Results of Simmon and Poole, 1978 (2)

The American Wood Preservers Institute submitted two unpublished microbial studies performed by Litton Bionetics, Inc. (LBI, 1977, 1978) to invalidate the gene mutation results of Simmon and Poole (1978). LBI, using the same assay (Ames Salmonella test) as Simmon and Poole, twice investigated the mutagenic potential of creosote and coal tar/creosote.

The rebutter considered the first Litton study (1977) to be negative; the second Litton study (1978) was positive. The rebutter's explanation for the positive results in 1978 was that the creosote may have aged and/or the rat liver preparation was different from that used in 1977. The rebutter states that the results of LBI's experiments show that those of Simmon and Poole cannot be relied upon as establishing the potential for human mutagenicity of creosote mixtures.

Agency Response: The Agency has reviewed the two studies submitted by the rebutter and concludes that, although LBI's 1977 mutagenicity assays performed with microbial systems were generally negative, the *S. typhimurium* strain TA 100 demonstrated a positive response. This strain, when tested in 1977 with metabolic activation by rat liver preparations, was positive for mutagenicity in one experiment and negative in another experiment. These conflicting results were not explained by the authors; however, it is unclear whether the same sample of creosote was analyzed and if the same rat liver preparation was used.

The Agency agrees that it is possible that there may have been differences in the rat liver preparations used in the studies. These differences could have been caused by different dose levels of Aroclor given to the rats, resulting in different activation characteristics of the rat liver preparations. (The doses were not reported by LBI.) As for the possibility of mutagenic products being formed upon aging of the creosote, this aging process will also undoubtedly occur in coal tar/creosote treating solutions.

Consequently, the Agency cannot accept the argument that because LBI's tests showed some degree of indeterminance the experiments performed by Simmon and Poole (1978) are invalid. The Agency concludes that the LBI 1977 study indeed showed a positive result for *S. typhimurium* TA 100, and the 1978 LBI study also showed positive results for *S. typhimurium* TA 1537 and TA 98.

Thus, the Agency does not consider LBI's results to be negative, as does the rebutter, nor that these results conflict with those reported by Simmon and Poole (1978). Thus, the Agency concludes that the data of Simmon and Poole are valid and supportive of the presumption of mutagenicity.

Rebuttal Comment 2: Reliability of the Results of Mitchell and Tajiri, 1978 (2)

The American Wood Preservers Institute claims that the study of Mitchell and Tajiri (1978) is unreliable for the purpose of demonstrating potential human mutagenicity of creosote mixtures. This is due primarily to the difficulty of interpreting the results of these experiments where only weak mutagenic activity is observed at the higher doses of creosote that caused pronounced cytotoxicity. The rebutter believes that observed mutagenic effects are only valid when a 10% or greater survival rate occurs in the detector cells treated with three increasing doses. Because the Mitchell and Tajiri study did not meet these criteria, the rebutter believes the results of this study are difficult to interpret.

In support of this position, the rebutter submitted an unpublished study. In these experiments, diploid human embryonic lung tissue was used to study the unscheduled DNA synthesis (UDS) caused by coal tar/creosote. These results showed evidence of weak mutagenicity at high (cytotoxic) levels of creosote.

Agency Response: The Agency agrees that the occurrence of cytotoxicity complicates the interpretation of the mutagenic responses observed by Mitchell and Tajiri (1978). However, even though the cytotoxicity is higher than desirable and masking of the mutagenic response (e.g., due to the selective killing of mutants or simply due to a low survival rate of all test cells) may have occurred, the Agency concludes that the Mitchell and Tajiri study demonstrated the mutagenicity of creosote mixtures in the test system.

The Agency has reviewed the study submitted by the rebutter and concludes that the LBI's results are consistent with those of Mitchell and Tajiri, showing that creosote induces unequivocal, albeit weak, unscheduled DNA synthesis in human diploid WI-38 cells in the presence of rat liver preparations.

Rebuttal Comment 3: Insufficient Data to Meet EPA's Guidelines for Multitest Evidence (2)

The American Wood Preservers Institute submitted the results of LBI experiments in which creosote mixtures were tested in five microbial systems. In all cases the results were negative for mutagenicity. The rebutter believes these results show creosote does not meet the RPAR risk criteria.

Agency Response: To meet the RPAR risk criteria for potential mutagenicity [40 CFR, Section 162.11(a)(3)(ii)(A)], a chemical must be shown to cause gene mutations in at least two of the thirteen test systems listed in the Proposed Guidelines [40 CFR, Section 163.84(b)(2)(i-iii]. As it is stated in the Agency's proposed guidelines [40 CFR Part 163 (III)(G)], "A compound would be considered a mutagen if it produced positive results in: two different kinds of tests for demonstrating gene mutations; a mouse specific locus test; or any kind of test for demonstrating chromosome aberrations." The positive results of Simmon and Poole (1978) and Mitchell and Tajiri (1978) provide more than sufficient evidence for meeting the mutagenicity criteria of the Guidelines. In addition, the positive results from the Salmonella assays and the human cell study (both submitted by this rebutter; see rebuttal comments 1 and 2) further support the presumption of mutagenicity.

Since two different kinds of tests (Simmon and Poole, 1978; Mitchell and Tajiri, 1978) showed positive results for mutagenicity of coal tar/creosote solutions, the five additional LBI studies showing negative results, although adding to the Agency's data base, do not rebut the presumption of mutagenicity in PD-1.

Rebuttal Comment 4: Bacterial Cell Membrane Uptake of Creosote (2)

The American Wood Preservers Institute asserts that the Salmonella strains used by Simmon and Poole (1978) are inappropriate for mutagenicity testing. This is because the cell membranes of these strains have a specific "defect" allowing greater uptake of polycyclic aromatic hydrocarbons (PAH's) than other cell membranes.

Agency Response: The Agency agrees with the rebutter that the *Salmonella* strains used in the Ames assay have an increased permeability toward the large heterocyclic molecules. These strains are used intentionally to mimic the permeability of mammalian cells as much as possible. This is also true for the *Bacillus subtilis* strain (used by LBI), which may have a permeability to heterocyclic compounds greater than that of the *S. typhimurium* strain used by Simmon and Poole. The Agency concludes that the *Salmonella* strains used by Simmon and Poole are appropriate for mutagenicity testing.

Rebuttal Comment 5: Appropriateness of Rodent Liver Homogenates for Activating Creosote Mixtures (2)

The American Wood Preservers Institute states that rodent liver enzymes are inappropriate for activating creosote mixtures prior to the Ames *Salmonella* test. The metabolic activity in rodent liver is much greater than that in either human skin tissue or human liver. The rebutter also points out that qualitative, as well as quantitative, differences exist between rodents and humans with regard to the metabolic pattern of polycyclic aromatic hydrocarbons (PAH's). Consequently, as specific metabolites of PAH's may be the actual mutagens, a PAH may produce mutagenicity in one species (e.g., rodents) and not in another (e.g., humans).

Agency Response: The Agency agrees that there are some qualitative and quantitative differences in enzymatic activity between rodent liver preparations used in the S. typhimurium mutagenicity assays and preparations from human liver or skin tissue. However, the bacterial mutagenicity assay is commonly used by scientists as a primary screening test for chemicals which have mutagenic potential. A positive result in these bacterial mutagenicity assays, although not intended to be the sole basis from which an extrapolation is made to a more complex biological endpoint (e.g., human mutagenicity), does indicate, however, that the presumption of mutagenicity for creosote and coal tar/creosote is not rebutted.

Rebuttal Comment 6: Extrapolation from In Vitro Experiments to Human Mutagenicity (2)

The American Wood Preservers Insititute points out that complex factors limit extrapolation from in vitro mutagenicity experiments to in vivo human mutagenicity.

Agency Response: The Agency agrees that it is difficult to extrapolate from in vitro mutagenicity to in vivo human mutagenicity. However, as discussed above (rebuttal comment 5), in vitro experiments like those of Simmon and Poole (1978) are intended to provide a rapid screening device for substances that have a potential human mutagenic effect. The results of the *S. typhimurium* assay are used in this document merely for qualitative purposes.

Rebuttal Comment 7: Potential for Nonsomatic Cell Mutations (2)

The American Wood Preservers Institute states that although bacterial mutagenicity assays may be relevant to skin tumors, the potential for nonsomatic (germ) cell mutations is slight, since these cells are distant from the site of contact with creosote and the creosote is not likely to be systemically distributed throughout the body.

Agency Response: The Agency rejects the assumption that creosote is not likely to be systemically distributed throughout the body. Studies performed by Ames *et al*. (1973) showed that when certain compounds are applied to the scalp of humans, they are ultimately found in the urine. Therefore, some compounds entering by dermal and/or inhalation routes may not necessarily stay at the site of contact but may be carried by the blood to other parts of the body. Whether this fails to occur with creosote can only be determined by experiments.

c. Summary of Rebuttal Comments Concerning Mutagenic Effects: Conclusion

The rebuttal comments do not invalidate the studies of Simmon and Poole (1978) or Mitchell and Tajiri (1978) as multitest evidence for mutagenicity. The presumption of mutagenicity for creosote and coal tar/creosote, as stated in PD-1, is not rebutted but is actually strengthened by the additional LBI studies provided by the American Wood Preservers Institute.

2. Analysis of Rebuttal Comments Concerning Oncogenicity

a. Basis of Presumption

i. Creosote

Dermal application of creosote has also been shown to produce skin tumors in mice (see Table II.B-1). Roe _et_ _al_. (1958), for example, found that dermal application of creosote to mice also produced lung tumors. Boutwell and Bosch (1958) found that creosote had the ability to initiate tumor formation when applied for a limited period prior to treatment with the promoter croton oil. Sall and Shear (1940) showed that the number of skin tumors following dermal treatment with creosote and benzo(a)pyrene was greater than that produced by benzo(a)pyrene or creosote alone.

It has also been reported that various kinds of workers occupationally exposed to creosote developed skin tumors (Henry, 1947; Lenson, 1956; O'Donovan, 1920; Cookson, 1924).

ii. Coal Tar

Many studies have shown coal tar to be oncogenic in laboratory animals. For example, dermal application of coal tar produced skin tumors in mice (Horton, 1961; Shabad _et_ _al_., 1971; Watson and Mellanby, 1930; Tsuitsui, 1918; Hueper and Payne, 1960; Deelman, 1962; Bonser and Manch, 1932; Gorski, 1959; Kennaway,

TABLE II.B-1

SUMMARY OF COAL TAR NEUTRAL OIL STUDIES

COAL TAR

Human Case Reports

Authors	Year	Substance and Type of Exposure	Occupation of Exposed Individual	Type of Tumor Response
Shambaugh	1935	Coal tar on repair needle held between lips	Fishermen - Net loft workers	Epidermal carcinomas of the lower lip
Mauro	1951	Handling of Coal Tar Pitch	Tar distillery workers	Cancer of skin, scrutum, cheek, and lip
Rosmanith	1953	Hot Coal Tar Vapors	Tar barrel filler	Spinocellular cancer in scar of cured erythematous lupus infection

TABLE II.B-1 (Continued)

COAL TAR

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Yamagiwa & Ichikawa	1915	Coal tar	Rabbits (Strain Undefined)	Papillomas of the ear (site of aplication)
Tsuitsui	1918	Bituminous coal tar	Mice - English	Papillomas, carcinomas and spindle cell sarcoma
Kennaway	1925	Coal tar products of 450 C, 560 C, & 1,250 C distillation temperature	Mice (Strain Undefined)	Skin tumors (higher rate of carcinogenesis at higher temperatures)

TABLE II.B-1 (Continued)

COAL TAR

Animal Studies
Dermal Exposure
(continued)

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Watson & Mellanby	1930	Dermal application of coal tar following dermal application of fats, oils, or tannic acid	Mice (Strain Undefined)	Increased tumor production
		Coal tar dermal application combined with addition of butter to diet	Mice (Strain Undefined)	Higher incidence of lung nodules
Bonser & Manch	1932	Scottish blast furnace tar; English crude tar	Mice (Strain Undefined	Papillomas and squamous cell carcinomas of the skin
Gorski	1959	Coal tar	Mice (Bn Strain)	Skin tumors (some malignant)
Hueper & Payne	1960	Coal tar	Mice - Black (C57 Strain)	Skin carcinomas
Horton	1961	Coal tars, coal tar mixture, benzo(a) pyrene mixture	Mice (C3M Strain)	Skin tumors in 75% of each group of animals
		Coal tar distillates	Mice (C3M Strain)	Skin tumors
Deelman	1962	Coal Tar	Mice (Strain Undefined)	Skin carcinomas and papillomas
Shabad *et al.*	1971	Coal tar ointments	Mice (C57 CBA Hybrid Strain)	Skin tumors

TABLE II.B-1 (Continued)

COAL TAR

Animal Studies
Inhalation Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Horton	1961	Coal tar fumes preceeded by inhalation of formaldehyde; coal tar fumes	Mice (C3M Strain)	Both groups developed Proliferative alveolar neoplasia; one mouse (group unspecified) developed a squamous cell carcinoma
Horton et al.	1963	Coal tar aerosol; Coal tar aerosol & gaseous formaldehyde	Mice (C3H Strain)	Both groups developed squamous cell tumors of lung and lung adenomas
Tye & Stemmer	1967	Coal tar; coal tar & phenolic & non-phenolic fractions of coal tar; non-phenolic fractions of coal tar	Mice (C3H/HeJ Strain)	Adenomas & carcinomas of the lung
Kinkead; McConnell & Specht; MacEwen & Vernot	1972-1974	Aerosolized coal tar - light oil & solid fraction removed	Mice (ICR-CF1) Mice (JAX--CAF1) Weanling rats (Sprague-Dawley) Yearling rats (Sprague-Dewley) Hamsters (Syrian golden) Rabbits (New Zealand white)	Mice developed skin tumors due to aerosolized material deposited on skin; Tumor response was not reported for rabbits, hamsters, or rats
MacEwen & Vernot; MacEwen et al.	1976	Aerosolized Coal tar	Mice (ICR-CF1) Mice (JAX-CAF1) Rats (Sprague-Dewley) Rabbits (New Zealand albino) Monkeys (Macaca Mullata)	Mice - Alveolargenic carcinoma and skin tumors; Rats - Squamous cell carcinomas; No tumor response was reported for rabbits or monkeys.

TABLE II.B-1 (Continued)

CREOSOTE

Human Case Reports

Authors	Year	Substance and Type of Exposure	Occupation of Exposed Individual(s)	Type of Tumor Response
Mackenzie	1896	Handling of Creosote	Worker who dipped railway ties in creosote	Warty elevation on arms; Papillmatous swellings on scrotum
O'Donovan	1920	Handling of Creosote	Workers who creosoted timbers	Skin cancer
Cookson	1924	Handling of Creosote	Creosote factory worker	Squamous epitheliomata on hand; epitheliomatous deposits in liver, lungs, kidneys and heart walls
Henry	1947	Handling of Creosote	37 men of various occupations	Cutaneous epitheliomata
Lenson	1956	Painting of Creosote	Shipyard worker	Malignant cutaneous tumors of the face

TABLE II.B-1 (Continued)

CREOSOTE

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Sall & Shear	1940	Creosote & benzo(a) pyrene	Mice (Strain A)	Accelerated tumor formation
Woodhouse	1950	Creosote oil	Mice (Albino; Undefined Strain	Papillomas & carcinomas
Lijinsky *et al.*	1957	#1 creosote oil	Mice - Swiss	Papillomas & carcinomas

TABLE II.B-1 (Continued)

CREOSOTE

Animal Studies
Dermal Exposure
(continued)

Author	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Poel & Kammer	1957	Blended creosote oils;	Mice (C57L Strain)	Papillomas & carcinomas metastatic growths in lungs and lymph nodes
		Light creosote oil	Mice (C57L Strain)	Papillomas
Boutwell & Bosch	1958	Creosote (Carbasota)	Mice (Albino - random bred)	Papillomas & carconomas
Roe *et al*.	1958	Creosote oil (Carbasota)	Mice (Strain Undefined)	Skin & lung tumors

TABLE II.B-1 (Continued)

COAL TAR NEUTRAL OIL

Animal Studies
Dermal Exposure

Authors	Year	Substance Tested	Animal & Strain	Type of Tumor Response
Cabot *et al.*	1940	Benzene Solution of neutral oil & benzo(a) pyrene	Mice - albino "market" mice	Inhibitory effect of tumor response as compared to tumor response with benzo (a)pyrene (effect credited to skin damage)
Berenblum & Schoental	1947	5 Coal tar neutral oil fractions	Mice (Strain Undefined)	All fractions but two were oncogenic
			Rabbits (Strains Undefined)	All fractions but one were oncogenic
Horton	1961	Coal tar neutral oils (maleic anhydride extracts)	Mice (Strain Undefined)	Produced tumors in 34.1 and 32.1 weeks

pTABc2

1925) and rabbits (Yamagiwa and Ichikawa, 1915). Exposure to coal tar via inhalation produced lung tumors in mice (Horton, 1961; MacEwen et al., 1976; Horton et al., 1963; Tye and Stemmer, 1967) and rats (MacEwen et al., 1976). Exposure of mice to coal tar aerosol also produced skin tumors (McConnell and Specht, 1973; MacEwen et al., 1976).

Dose-response relationships for oncogenicity have been found several times [e.g., skin tumors in mice following dermal (Horton, 1961) or inhalation (McConnell and Specht, 1973; MacEwen and Vernot, 1976) exposure]. Horton (1961) and McConnell and Specht (1973) also found a dose-response relationship for the latency period (time until diagnosis of tumors).

Skin cancer has also been reported in fishermen and others involved with the repairing and retarring of fishing nets (Shambaugh, 1935), coal tar distillary workers (Mauro, (1951), and a coal tar barrel filler (Rosmanith, 1953).

iii. Coal Tar Neutral Oil

As with creosote and coal tar, dermal application of coal tar neutral oil has been shown to produce skin tumors in mice (Horton, 1961). Berenblum and Schoenthal (1947) found that several chromatographic fractions of coal tar neutral oil produced skin tumors when dermally applied to mice. Cabot et al. (1940) found that mixtures of coal tar neutral oil with benzo(a)pyrene produced fewer tumors than benzo(a)pyrene alone, but suggested that this inhibiting effect was due to skin damage.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: Reliability of Old Case Reports of Skin Cancer (2)

The American Wood Preservers Institute asserts that the case reports of skin cancer from occupational exposure to creosote are not sufficient evidence that creosote causes skin cancer in modern treatment plant workers. This is because many of these exposures occurred before World War II, before "current hygienic practices and safety precautions" were in effect. Furthermore, the rebutter states that the reports are anecdotal in nature and do not contain enough details to rule out other common causes of skin cancer.

Agency Response: As with case reports in general, it is difficult to rule out entirely a role in these skin cancer cases for factors other than creosote. The Agency believes, however, that the early case reports suggest creosote has the capability of causing skin cancers. Although not providing direct evidence for a cause-effect relationship, these studies do provide supporting evidence for the Agency's concern that long-term exposure to creosote may pose a skin cancer hazard. The studies also complement the numerous laboratory animal studies showing creosote to be an oncogen (see Table II.B-1).

The rebutters present neither firm evidence that the current formulations of creosote are safer than the formulations used before World War II nor evidence as to the extent or effectiveness of "current hygienic practices and safety precautions."

Rebuttal Comment 2: Small Number of U.S. Case Reports (149)

Allied Chemical Corporation questioned the skin cancer hazard from creosote manufactured and used in the United States. The rebutter points out that, of the mere eight reports of skin cancer among exposed workers cited in PD-1, only two were from the United States. One of these reports concerns an individual who was a painter for 41 years prior to a 3-year job working with creosote. The other report deals with a fisherman working with tarred nets. The rebutter states that exposures to paint solvents could have caused the face cancer of the painter, and that exposure to tarred fishing nets is not relevant to the use of creosote as a wood preservative. The rebutter recognizes, however, that most experts agree that long-term dermal exposures to high levels of creosote poses a possible skin cancer hazard. The rebutter presented a new survey of Allied plant workers documenting skin lesions that these workers had incurred. The dermatologists questioned in the survey concluded that proper personal hygiene and periodic medical surveillance would prevent serious skin diseases.

Agency Response: Although the rebutter provides no evidence showing that paint solvents may have contributed to the cause of the painter's cancer, the Agency acknowledges the possibility that such may have been the case. Similarly, although the rebutter has submitted no data,the tar used for the fishing nets may indeed be qualitatively different from that used for wood preservation.

Still, the basis for the Agency's concern is not limited to the eight human case reports cited in PD-1, but also includes the 21 animal studies on coal tar and creosote (see Table II.B-1). The Agency agrees with the rebutter that creosote exposure, if continued for a long duration at high levels, constitutes a skin cancer hazard.

Rebuttal Comment 3: Reliability of Henry, 1947 (143)

West European Tar Industries criticizes the case report study of Henry (1947) which reviewed 3,753 cases of cutaneous epitheliomata. The rebutter points out that NIOSH discounted this paper because Henry "did not describe the bases for his conclusions."

Agency Response: The Agency agrees with NIOSH and the rebutters that the lack of certain information in Henry's report, such as the number of workers exposed to creosote, makes it difficult to quantify the relationship between exposure and cutaneous cancer. However, Henry's paper does provide strong evidence that the site of cutaneous cancer was associated with the nature of a worker's occupation, thereby supporting the occupational basis of these cancers.

Rebuttal Comment 4: Health Records of Creosote-Exposed Workers (151, 193)

The Association of American Railroads submitted a summary of a 4-year study which reported 971 dermatitis or burn cases caused by creosote in railroad workers. The rebutter also summarized the health records of about 90 workers in two railroad tie treating plants. These records cover a period of about 30 years. The rebutter believes that, although workers exposed to creosote may develop "initiative dermatitis" or "transient eye involvement," the studies provide no evidence of an increased incidence of creosote-related skin cancer.

In another rebuttal comment, Samuel Cabot, Inc. states that, following a review of that company's employee files, no "report of any critical or permanent illness linked to employee exposure to creosote" was found.

Agency Response: The summary reports submitted by the rebutters do not indicate that the studies were specifically designed to detect an increased incidence of skin cancer. For example, they do not provide mortality, morbidity, or exposure data.

Also, it appears that the studies consist of an examination of voluntary reports of individuals' medical complaints rather than systematic surveillance of skin diseases possibly related to creosote exposure. Therefore, the information provided by the rebutters is not definitive evidence that creosote is not associated with induction of skin cancer.

Rebuttal Comment 5: New Epidemiology Studies (1)

Koppers Company submitted three studies in support of their conclusion that workers exposed to creosote are not subject to an excess risk of cancer. Two of the studies are epidemiological (proportional mortality), and the third is a summary of workers' health examinations.

Agency Response: The Agency does not believe these studies either support or refute the rebutter's conclusion. The studies are deficient because in each one a biasing factor exists due to the method of selection of deaths. For example, it appears that individuals who spent a period of years working for Koppers and then left for other employment prior to retirement were not counted. The Agency assumes that the data included only individuals who died while employed by Koppers or after retirement from Koppers. Individuals who left the company because of illness, and later died from such illness, may not have been included in the data. The Agency concludes that, as these studies did not have the proper controls that should be present in good epidemiological investigations, the studies are incomplete and inconclusive.

The third study is merely a summary of healthy workers' health examinations. Much follow-up work is required before this information can be of use in detecting serious diseases.

Rebuttal Comment 6: Metabolism of Creosote Components (149)

Allied Chemical Corporation states that the polycyclic aromatic hydrocarbons (PAH's) contained in creosote are metabolized and excreted in mammals, implying that these biological functions automatically reduce or eliminate the oncogenicity of these compounds.

Agency Response: While it is true that mammals do metabolize both oncogenic and nononcogenic PAH's, it is not true that all the metabolites of these compounds are innocuous. Some PAH's are metabolized to active oncogens regardless of the route of administration or dose level (Dipple, 1976). Also, it remains possible that some oncogenic PAH's exert their biological influence before they can be metabolized completely. Thus, PAH's may pose an oncogenic risk to exposed humans.

Rebuttal Comment 7: "Anticarcinogenic" Activity of Creosote Components (2)

The American Wood Preservers Institute states that creosote solutions contain "anticarcinogenic" substances as well as suspected oncogens. The rebutter suggests that the consequence of this may be that the potential for any oncogenicity, due to the presence of "well-established carcinogens," is cancelled out.

Agency Response: The Agency is not aware of any evidence that the presence of "anticarcinogenic" substances in creosote solutions counteracts the oncogenic components. Although creosote may contain some inhibitory compounds, it also clearly contains both carcinogenic initiators and promoters, as well as complete carcinogens. Also, numerous laboratory animal studies cited in PD-1 adequately demonstrate that whole creosote is oncogenic (see Table II.B-1).

Rebuttal Comment 8: Dermal Application of Coal Tar Medicinals (191)

The Joint Industry Coal Tar Committee cited the testimony of P.E. Weary and E.M. Farber before the Food and Drug Administration's Antimicrobial Panel II (DHEW, 1977) as evidence that even coal tar medicinals, which are applied directly to the skin, do not cause skin cancer. Dr. Weary concluded (page 11 of the DHEW document) that in his 21 years of dermatologic practice, he had found no solid evidence that coal tar products cause skin cancer. Dr. Farber sent questionnaires to 91 physicians who had been using these products for at least 30 years. Again, there was no indication that these products caused any skin cancers (page 300 of the DHEW document).

Agency Response: Although testimony of this type is informative, these comments do not rebut the oncogenicity presumption for creosote. In the same symposium transcript (pp. 181-4) it was concluded that coal tar medicinals contain at least four agents that cause tumors in laboratory animals: benzo(a)pyrene, beta-naphthalamine, o-toluidine, and quinoline. Also, Dr. Hoffman points out (page 184) that a review of the literature in 1966 (Greither *et al.*, 1966) revealed that "thirteen cases of skin cancer were reported in patients who used coal tar preparations. Of these cases two were also treated with arsenicals."

In conclusion, the Agency is unaware of any adequate long-term studies to characterize the oncogenic effects of the use of coal tar medicinals in the induction of skin cancer.

Rebuttal Comment 9: Reliability of Mouse Skin-Painting Studies (193)

Samuel Cabot, Inc. attacks the utility of mouse skin-painting studies as a reliable basis of establishing the oncogenicity of creosote. In the opinion of this rebutter, the studies lack adequate controls, detailed information on dose levels, route of administration, sex, strain and species of test animals, and experimental design. Weisburger (1975) is cited in support of invalidation of these earlier studies.

Agency Response: The Agency agrees that two of the six studies had no controls. Nevertheless, the consistent positive response in these studies cannot be ignored. Older studies cannot automatically be invalidated due to lack of conformity to present-day protocols. Also, Dr. Weisburger's article merely listed several variables which affect the carcinogenic response in animal experiments. The mere listing of these variables does not invalidate these specific studies.

Rebuttal Comment 10: Reliability of Horton et al., 1963 (149)

Allied Chemical Corporation suggests that the positive oncogenic response found by Horton et al. (1963) with coal tar aerosols may have been due to aggravation by the formaldehyde carrier.

Agency Response: The positive oncogenic response in the mouse study with coal tar aerosols is not explained by the effect of formaldehyde because the group treated with coal tar alone gave a greater response than the group treated with coal tar plus formaldehyde.

Rebuttal Comment 11: Inappropriateness of Rodents as Models for Oncogenicity (2)

The American Wood Preservers Institute questioned the reliability of rodent species as models for oncogenicity in man. The rebutter states that these species are inappropriate due to major differences in the metabolic, pharmacokinetic, and biochemical characteristics of rodents and man.

Agency Response: The Agency finds no merit in the rebutter's comment. It is accepted Agency policy to rely on the results of animal studies to demonstrate the oncogenic potential of a chemical agent. This policy, as stated in the Interim Cancer Guidelines (FR 41:21402-21405, May 25, 1976), is that "a substance will be considered a presumptive cancer risk when it causes a statistically significant excess incidence of benign or malignant tumors in humans or animals."

The scientific rationale for using animal studies for this purpose is multifaceted. First, very few industrial chemicals and processes have been subjected to adequate epidemiological studies to determine whether or not they cause carcinogenic effects in workers. Second, epidemiological studies are insensitive and little weight can be placed on surveys which do not show positive results. Third, many industrial chemicals have not been in production long enough for any effects to be observable, bearing in mind the long latent periods for chemically-induced cancers. Fourth, it would be unethical to wait for evidence of harm in exposed workers when risks can be established relatively quickly by animal experimentation.

A risk assessment which relies solely on animal data would be less reliable for humans in a situation where definite metabolic pathway differences can be shown between animals and humans. Since the rebutter presented no clearcut evidence of such differences for the metabolism of creosote, there is no basis for qualifying the risk assessment on metabolic grounds.

Rebuttal Comment 12: Lack of Oncogenic Response to Benzo(a)pyrene (193)

Samuel Cabot, Inc. cites Dr. Weisburger (1975), pointing out that after 8 to 10 years of skin applications to primates of some known oncogens, including benzo(a)pyrene, no tumors were observed. The rebutter submits this as evidence that creosote is not oncogenic.

Agency Response: The major purpose of this section of Dr. Weisburger's article was to show the inter-species variation in response to oncogens, and not to demonstrate that benzo(a)pyrene is nononcogenic. Moreover, on page 279 (Table 8.4) of her article, Dr. Weisburger lists both coal tar and creosote as human oncogens.

c. Summary of Rebuttal Comments Concerning Oncogenic Effects: Conclusion

The rebutters have presented no substantial information which shows that creosote does not pose an oncogenic risk to humans.

Abundant data from animal experiments (Table II.B-1) show that creosote induces squamous-cell carcinomas and papillomas of the skin, and adenomas and carcinomas of the lung. These positive results in laboratory animals are supported by the numerous case reports of skin cancer in people heavily exposed to creosote. Thus, the original conclusions presented in PD-1 are still valid, and the presumption of oncogenicity for creosote is not rebutted.

3. Analysis of Rebuttal Comments Concerning Human Exposure

Rebuttal Comment 1: Composition of Coal Tar and Its Effects on Carcinogenicity (2)

The American Wood Preservers Institute states that the composition of creosote produced and used in the U.S. today may be qualitatively different from the test substances used in the laboratory animal cancer studies cited in PD-1. The rebutter points out that, although the chemical characteristics of these test substances were not described in the studies, a number of the studies were conducted many years ago and/or in foreign countries where creosote production methods differ from the methods used in this country. The rebutter believes, therefore, that these studies are not relevant to the potential oncogenicity of creosote produced in the U.S.

Agency Response: As discussed earlier (see Section I.C.1.a), coal tar and creosote are complex mixtures containing hundreds of identifiable constituents. The duration, temperature, and nature of the coking operation are likely to have an effect on the products formed, particularly during secondary reactions. For example, the higher the temperature during coking (and the longer the duration of coking), the more complete will be the formation of secondary products such as polynuclear aromatic hydrocarbons (PAH's). PAH's are fused ring compounds, some of which have been identified as oncogens.

While the Agency agrees that the various constituents of creosote derived from different sources and methods may differ in their quantitative distribution, the classes of chemicals (including PAH's) will be basically the same in the different batches of creosote (McNeil, 1952).

Rebuttal Comment 2: Relationship of Animal Inhalation Studies to Wood Preservative Plant Workers (2)

The American Wood Preservers Institute points out that aerosolized coal tar was used in the laboratory animal inhalation studies cited in PD-1. The rebutter believes these studies are not relevant to the evaluation of oncogenic risk to workers exposed to creosote vapors at wood-treating plants. This is because aerosolized coal tar contains greater concentrations of 4- and 5-ring PAH's than creosote vapors at these plants.

The rebutter believes that treatment plant workers are exposed to only "low" levels of benzene-soluble polycyclic particulate organic matter (PPOM). In the opinion of the rebutter, the organic matter that workers are primarily exposed to is in the vapor phase, and this fraction contains, according to the rebutter, only lower molecular weight, nononcogenic compounds.

In support of this position, the rebutter submitted the results of air monitoring studies conducted at several Koppers and Kerr-McGee plants. Some of the data from these experiments are presented in Tables II.B-2 and II.B-3.

TABLE II.B-2

Exposure of Switchman in a Creosote Plant Showing GC Analysis of Vapors and Filterable Matter

	No. Rings	Air Emissions (mg/m^3) Collected in Carbon[a]	Collected on Filter[b]
Benzene[c]	1	0.012	---
Toluene[c]	1	0.032	---
Xylenes/Ethylbenzene[c]	1	6.3	---
Napthalene	2	0.47	---
Methylanaphthalenes	2	0.037	---
Dimethylnaphtalenes	2	<0.01	---
Acenaphthene	3	0.036	0.0007
Dibenzofuran	3	---	0.0008
Fluorene	3	<0.01	0.004
Phenanthrene/ Anthracene	3	<0.01	0.02
Fluoranthene	4	---	0.001
Pyrene	4	<0.01	0.001
Unknown 1	-	---	0.005
Unknown 2	-	---	0.002
Benzo(a)pyrene	5	---	<0.0003
1,2- and/or 2,3-Benzofluorene	4	---	<0.0003
Benz(a)anthracene	4	---	<0.0003
Chrysene	4	---	<0.0003
Benzo(k)fluoranthene	5	---	<0.0003
3,4-Benzofluoranthene	5	---	<0.0003
Perylene	5	---	<0.0003
1,2,3,4- and/or 1,2,5,6-Dibenzanthracene	5	---	<0.0003
1,12-Benzoperylene	6	---	<0.0003
Benzene-Soluble Particulate		---	0.10[a]
Total Particulate		---	0.21[a]

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a. Based on Sample 4054-180-3A.

b. Based on Sample 4054-181-4, taken on freshly pulled tram cars at various intervals, 8/16/78 thru 8/18/78, then propritioned on the basis of benzene solubles to the 0.10 mg/M^3 level reported.

c. These constituents are found in the vapor drying solvent and are not present in creosote/coal tar solutions.

TABLE II.B-3

Vapor Phase Exposure to Wood Preservative Plant Workers[a]

Operator/Job Category	Number of Samples Taken	Concentration in Breathing Zone (mg/m^3)[b]					
		naphthalene		methylnaphthalene		acenaphthene	
Personal Samples		ave	range	ave	range	ave	range
switchman	5	1.02	0.44-2.1	<0.1	0.4-<0.2	0.07	0.02-<0.1
test borer	2	0.97	0.23-1.7	0.23	<0.2-0.25	0.08	0.07-<0.1
load out man	1	1.5	-	0.32	-	0.11	-
doorman	3	1.4	0.92-1.9	<0.2	<0.2	<0.1	<0.1
treating operator	1	2.2	-	0.24	-	0.21	-
locomotive operator	2	3.7	1.0-6.3	<0.2	<0.2	<0.1	<0.1
treating engineer	1	1.3	-	<0.2	-	<0.1	-
clean up man	1	0.6	-	<0.2	-	<0.1	-
Area Samples							
doorman platform	2	8.95	6.9-11.0	0.99	<0.2-1.77	0.31	<0.1-0.52
dehydrator	1	42	-	4.1	-	1.6	-

a. Adapted from Koppers, 1978.
b. Samples were analyzed by GC-FID following collection on charcoal. Only three constituents were identified. Note particularly the relatively high exposure levels detected in the area samples.

Agency Response: Sufficient data have not been collected to categorically identify the specific constituents present in the breathing zone of treatment plant workers. The data presented in Table II.B-2 is derived from one, unreplicated air sample analyzed for individual PAH compounds. It should be noted, however, that both pyrene and fluoranthene, found in the worker's breathing zone, are 4-ring PAH's. Both of these chemicals have boiling points close to 400°C. Also, the presence or absence of the known oncogen chrysene in the vapor phase was not examined. In the earlier study where specific chemicals were also analyzed (Table II.B-3), the levels of only naphthalene, methylnaphthalene, and acenaphthene in the vapor phase were determined.

Consequently, as both vapor phase and airborne particulate phase material are present in the creosote workers' breathing zone, these workers are exposed to some 4-ring PAH's, some of which may be oncogenic, via inhalation. Additionally, the Agency is concerned that no sampling studies have been reported in which the vapor phase is analyzed for lower boiling oncogenic amine constituents of creosote, such as toluidines and xylidines (Nestler, 1974).

Rebuttal Comment 3: Residues of Benzo(a)pyrene in Mussels (2)

In PD-1, two studies by Dunn and Stich (1975, 1976a, 1976b) were cited as evidence that benzo(a)pyrene may leach out of creosote-treated pilings, and then be absorbed by mussels attached to those pilings. The rebutter criticizes the Agency for not considering the possibility that diesel motorboat engines may be the source of benzo(a)pyrene. The rebutter cites a National Academy of Sciences report (NAS, 1972) showing that two-cycle engines burning an oil and fuel mixture in a ratio of 1:33 may emit as much as 11 mg of benzo(a)pyrene per gallon of fuel consumed.

Agency Response: The Agency agrees with the rebutter that the Dunn and Stich papers do not establish that creosote-treated pilings are the source of the benzo(a)pyrene in the mussels.

Rebuttal Comment 4: Reliability of NIOSH, 1977 (143)

West European Tar Industries criticizes the NIOSH (1977) monitoring study, cited in PD-1, for using cellulose back-up pads behind the sampling filter. The rebutter states that contaminants from the cellulose pads interfere with proper measurement of PPOM.

Agency Response: The Agency agrees that the results of the NIOSH (1977) study are dubious due to possible contamination from the cellulose pads. Consequently, this study will not be used in the Exposure Analysis (Section II.B.4).

4. Revised Human Exposure Analysis

a. Chemistry

As pointed out in Section 1.C.1.a, coal tar is an extremely complex mixture produced by coking, the high temperature carbonization of coal. Creosote is a lower boiling distillate of coal tar. Both mixtures vary in composition, depending on the temperature of coking and the source of the coal used (McNeil, 1952; Nestler, 1974). In distilling coal tar to form creosote, the lower molecular weight compounds are concentrated. The balance of polynuclear aromatic hydrocarbons (PAH's) in creosote contain one to four rings, although larger PAH's such as benzo[a]pyrene, benzo[j]fluoranthene, and benzanthracene have also been positively identified (Lijinsky et al., 1957). Lorenz and Gjovik (1972) have identified the major constituents in creosote. They found that 18 compounds (Table II.B-4) accounted for about 75-85% of the total volatile creosote material. They also found variation in the relative percentage of individual components in different creosote samples. In addition to aromatic hydrocarbons, creosote also contains smaller amounts of phenolic constituents as well as nitrogen-, oxygen-, and sulfur-containing heterocyclic ring systems and aromatic amines.

TABLE II.B-4

Major Components of Creosote[a]

Component	Approximate Percentage	Boiling Point (°C)
Naphthalene	3.0	218
2-Methylnaphthalene	1.2	241.05
1-Methylnaphthalene	0.9	244.64
Biphenyl	0.8	255.9
Dimethylnaphthalenes	2.0	268
Acenaphthene	9.0	279
Dibenzofuran	5.0	287
Fluorene	10.0	293-295
Methylfluorenes	3.0	318
Phenanthrene	21.0	340
Anthracene	2.0	340
Carbazole	2.0	355
Methylphenanthrenes	3.0	354-355
Methylanthracenes	4.0	360
Fluoranthene	10.0	382
Pyrene	8.5	393
Benzofluorenes	2.0	413
Chrysene	3.0	448

a. Adapted from Lorenz and Gjovik (1972).

b. Description of Treatment Process

As will be discussed in greater detail in Part III, creosote and blended creosote/coal tar solutions are applied to wood predominantly by the pressure treatment process. The entire treatment system is closed and there is no need for direct worker contact with the creosote. The material arrives by truck or rail and is pumped into holding tanks where it is weighed. If the delivered material is a creosote/coal tar solution, as in treatment of railroad ties, the solution is premixed, so that no mixing or manual transfer operations are required at the treatment plant. After seasoning, the wood is placed on railway tram cars which are then placed in the pressure chamber. The treatment chambers vary in size but are generally 85 to 135 feet in length and 6 to 8 feet in diameter. The treatment process itself involves pressurization; thus, the chambers are airtight.

Treatment times vary, but they generally range from 6 to 7 hours for each charge of material. Following treatment, a vacuum is generally applied to withdraw excess creosote. The chamber door is then cracked open for about 15 minutes, while still under vacuum, prior to withdrawal of the tram cars. The greatest opportunity for worker exposure appears to occur during the mechanical withdrawal of the tram cars from the chamber because air and steam turbulence may result in suspension of particulate and vaporized material when the cylinder door is opened. The wood laden cars are coupled to an engine and withdrawn to a storage area where the wood remains until shipment to the buyer. Drippage of creosote is collected in ditches along the tracks and is pumped to a collecting pond along with creosote that has dripped from the pressure chambers at the time the charge was removed.

Handling of treated wood is performed either mechanically or with metal utensils, so that direct dermal exposure to the treated wood is apparently minimal. Bore samples of treated wood are taken routinely to determine the extent of creosote penetration into the wood. The number of plant workers potentially exposed to creosote will vary from plant to plant, depending on the number of treatment chambers. The introduction of creosote into chambers is performed by treatment operators in a control house near the chambers. The assistant treatment operator is responsible for opening and closing the pressure chamber door and otherwise assisting the treatment operator. No direct contact with creosote treatment solution is necessary, but in older facilities leakage of creosote from old pipes and fittings combined with poor ventilation may result in relatively high exposure to indoor operators. Roughly 4,000-5,000 workers are involved in commercial pressure treatment with creosote (USDA-States-EPA, 1980; McMillan, 1976).

c. Revised Human Exposure Analysis for Specific Exposure Situations

i. Pressure Treatment

The bulk of the inhalation exposure data curently available for creosote treatment workers was collected by a gravimetric technique. This method involves the collection of suspended particulate matter (called polycyclic particulate organic matter, or PPOM) from the air, extraction of the collected material with benzene, evaporation of the solvent, and weighing of the dried extract. The precision of this method has been estimated at ± 9%; the accuracy is low because of incomplete extraction (Koppers, 1977). Insufficient data exist, however, to properly evaluate the precision and accuracy of this method. Most important, this method does not identify any constituents of the airborne particulate fraction.

Potential inhalation exposure of creosote pressure treatment workers has been measured at 11 commercial treatment plants using this gravimetric method (Table II.B-5). The overall average benzene-soluble particulate air concentration is about 0.07 mg/m^3. The probable range of ambient air concentrations of these particulates in these studies is 45 to 95 ug/m^3, since data from several sources indicate that the results of benzene soluble PPOM analyses may have an uncertainty of as great as 50% for samples containing 50 ug of material.

TABLE II.B-5

Combined Results of Koppers/Kerr-McGee Monitoring Studies[a,b]

Operator/Job Category	Number of Samples Taken	Concentration of Benzene-Soluble Particulates in Breathing Zone (mg/m^3)	
		Average	Range
Personal samples			
locomotive operator	25	0.05	0.01-0.21
treating operator	44	0.06	0.02-0.20
switchman	35	0.05	0.01-0.21
tie load out	17	0.05	0.01-0.12
oil unloader	7	0.07	0.01-0.16
test borer	8	0.05	0.02-0.10
load out checker	1	0.04	0.04
crane crewman	5	0.09	0.05-0.17
oil handler	4	0.06	0.03-0.10
effluent man	3	0.07	0.04-0.12
tie roller	1	0.08	0.08
doorman	6	0.06	0.01-0.14
A & B operator	6	0.20	0.05-0.61
treating helper			
A & B truck lift operator	3	0.07	0.06-0.08
lift operator	1	0.40	0.40
A & D grapple	3	0.15	0.04-0.30
boiler fireman	4	0.17	0.04-0.52
locomotive helper	4	0.06	0.03-0.13
treating engineer	3	0.03	0.01-0.07
shipping supervisor	1	0.06	0.06
crane chainer	6	0.08	0.02-0.12
tie leveler	2	0.04	0.02-0.06
clean up	1	0.02	0.02
Totals	196	0.07	0.01-0.61
Treatment area samples			
treated storage yard	2	0.06	0.06
storage tanks	1	0.06	0.06
fuel tank platform	1	0.04	0.04
doorman platform	2	0.03	0.02-0.04
dehydrator	1	0.10	0.10

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a. From AWPI (1979) and Koppers (1978)

b. Several outlyer samples were not included. These include one switchman sample (suspected contamination) and one tie load out sample (possible contamination). Samples were taken during day and night shifts over a several year period at various wood preserving pressure treatment plants. Analyses were performed by a non-specific gravimetric techniques. Note that some operations involve relatively high levels of exposure e.g. A & B operator, A & D grapple, lift operator, and boiler fireman.

Sufficient data are not available to identify specific constituents present in airborne particulates in the breathing zone of treatment plant workers. One study of exposure to creosote using a 60/40 creosote/coal tar blend identified several particulate phase consituents in a single, unreplicated sample (AWPI, 1980). The compounds were collected on a fiber glass and silver membrane. The results of this study (Table II.B-2) are not necessarily representative of the other workers at the same plant or of other wood treatment plants. This area sample contained naphthalene (0.47 mg/m^3), methyl naphthalenes (0.037 mg/m^3), acenaphthene (0.0007 mg/m^3), dibenzofuran (0.0008 mg/m^3), fluorene (0.004 mg/m^3), phenanthrene/anthracene (0.02 mg/m^3), fluoranthene (0.001 mg/m^3), pyrene (0.001 mg/m^3), and two unknowns (0.007 mg/m^3). The remaining 0.10 mg/m^3 of collected benzene-soluble particulates was not characterized. It is important to note that flouranthene and pyrene, two high boiling constituents of creosote/coal tar (b.p. 382°, 393°C, respectively), were detected and that benzo(a)pyrene may be present at less than 0.3 ug/m^3 (level of detection). Creosote contains roughly 3.0 ± 0.7% by weight chrysene, a known carcinogen (Lorenz and Gjovik, 1972). If present, chrysene was below the limit of detection in the particulate phase, as sampled by Koppers. However, its presence or absence in the vapor phase in the same study was not examined.

Vapor phase material is not collected on the silver membrane or glass fiber filters used in the gravimetric sampling method. In the same Koppers plant in an analysis of the vapor phase material collected in a charcoal tube, naphthalene (0.47 mg/m^3), methylnaphthalenes (0.037 mg/m^3), and acenaphthene (0.036 mg/m^3) were found (Koppers, 1980). In an earlier attempt to measure several vapor phase constituents of creosote/coal tar in pressure treatment plant worker breathing zones, exploratory studies were performed by Koppers (AWPI, 1979) at two wood preserving plant sites, Susquehanna and Little Rock. Analyses were performed by temperature programmed gas chromatography-flame ionization detection (GC-FID) following collection with charcoal tubes and desorption by carbon disulfide. Samples were analyzed for naphthalene, methylnaphthalene, and acenaphthene. The results of these analyses are given in Table II.B-3.

Table II.B-5 gives the average values and ranges of PPOM to which workers are exposed in the course of routine operations. Nonroutine operations, such as entering the treatment chamber for cleaning, may occur several times yearly. Workers involved in according to AWPI these latter operations are apparently provided with suitable respirators and protective clothing, as they probably have a greater than ordinary potential for exposure to creosote.

Adequate vapor phase sampling has not been performed to date to categorically rule out the presence of such PAH compounds as benzo(a)pyrene, fluorene, phenanthrene/anthracene, flouranthene, pyrene or other compounds which might occur at low concentrations (ug/m^3 range). Further, no sampling studies have been reported in which the vapor phase is analyzed for oncogenic aromatic amine constituents of creosote such as toluidines and xylidines. It is possible compounds of this type, which have relatively low boiling points (Nestler, 1974), are present in the air of creosote treatment plants. Additional studies using sensitive and selective analytical methods would be required before definitive conclusions could be drawn regarding the presence of potentially oncogenic and mutagenic compounds in worker breathing zones.

There is no quantitative information regarding potential dermal exposure to creosote. That such exposure may indeed occur, however, is evidenced by reports of skin sensitization and burns, conjunctivitis, and eye irritation (McMillan, 1976; NIOSH, 1977; see also PD-1). In a study of roofers (NIOSH, 1977), skin symptoms were observed on the forehead and face. In some cases workers experienced burning sensations through their shirts and gloves.

ii. Nonpressure Treatment

Commercial groundline treatment of creosote to poles already in service is sometimes carried out to control fungal decay. Approximately 300 people are involved in the application of about 500 thousand pounds of creosote annually for groundline treatment (USDA-States-EPA, 1980). No exposure data are available for this use.

Noncommercial brush, dip, spray, and soak treatments using creosote are carried out by homeowners, farmers, and landscapers for control of decay. Approximately 50,000 people apply about 2 million pounds of creosote annually (USDA-States-EPA, 1980). Although no exposure data are available for this use, the Agency expects that inexperienced persons using these over-the-counter products have the potential, albeit intermittent, for greater exposure to creosote and creosote vapors than do commercial applicators.

iii. End Use

There exists no quantitative inhalation or dermal exposure data for workers or members of the general population who install, handle, or come into casual contact with creosote-treated wood. The major end uses for this wood are railroad ties (USDA-States-EPA, 1980).

These ties are generally mechanically installed and little dermal contact is expected. The USDA-States-EPA assessment team (1980) has made qualitative estimates of worker exposure resulting from end use of creosote-treated wood. These estimates are cited in Table II.B-6. Full discussion of end-use patterns is found in the USDA-States-EPA report.

Table II.B-6

Summary of qualitative exposures to products treated with creosote-type preservatives at point of end use

Product	Exposed At								
		Installation			Inspection, Maintenance			Casual Contact	
	Number Exposed[a]	Intensity of Exposure[b]		Number Exposed[a]	Intensity of Exposure[b]		Number Exposed[a]	Intensity of Exposure[b]	
		Skin Contact	Inhalation		Skin Contact	Inhalation		Skin Contact	Inhalation
Crossties[c]	B	5	3	B	5	5	C	5[d]	5
Poles	B	5	3	B	5	5	C	5[d]	5
Lumber and timbers—outdoors or in well ventilated buildings[e]	C	2-5	3	C	5	5	C	5[d]	5
Lumber and timbers—in enclosed, poorly ventilated buildings	A	2-5	3	A	5	5	A	5[d]	5
Switch ties and crossing planks	B	2-5	3	B	5	5	C	5[d]	5
Piling—foundation	B	5	3	NA[f]	5	5	NA[f]	—	—
Piling—marine	B	5	3	C	5	5	C	5[d]	5
Fence Posts	C	2-5	3	C	5	5	C	5[d]	5
Mine ties and timbers	B	2-5	3	B	5	5	C	5[d]	5
Crossarms	B	5	3	B	5	5	NA[f]	—	—
Block flooring	A	5	3	B	5	5	B	5	3

a. A = <1,000; B = 1,000 to 10,000; C = >10,000.

b. 1 = consistent high exposure; 2 = occasional high exposure; 3 = consistent moderate exposure; 4 = occasional moderate exposure; 5 = minimal exposure.

c. Most crossties are installed mechanically: For exposure data for hand installed ties see switch ties and crossing planks.

d. Wood products pressure treated with some creosote formulations have a tendency to bleed leaving concentrated deposits of creosote/coal tar on the surface of the wood. Casual contact with such products causes occasional moderate exposure to skin contact.

e. Includes pressure treated bridge timbers, piers, retaining walls, fencing, shelters, and pole barns.

f. NA- not applicable

5. Qualitative Risk Assessment for Mutagenicity

In Section II.B.1, the Agency summarized the studies cited in PD-1 on the potential mutagenicity of creosote and creosote/coal tar blends, and analyzed the rebuttal comments concerning the mutagenicity of creosote and creosote/coal tar blends. The Agency concluded that the data presented in PD-1 demonstrated that different creosote fractions have mutagenic activity for several strains of Salmonella typhimurium after metabolic activation (Simmon and Poole, 1978). It was also concluded that creosote and creosote/coal tar blends have mutagenic activity for mouse lymphoma cells following metabolic activation (Mitchell and Tajiri, 1978). Studies submitted during the rebuttal phase of the RPAR review showed that creosote gave positive mutagenic responses in S. typhimurium strains TA 1537 and TA 98 (see rebuttal comment 1, Section II.B.1.b). The results of other experiments submitted by the rebutter (see rebuttal comment 2, Section II.B.1.b) demonstrated that creosote can give rise to unscheduled DNA synthesis in human WI-38 cells. Based on these results for creosote, creosote/coal tar blends, and particular chemical components of creosote, the agency concluded that the data base on mutagenicity met or exceeded the mutagenicity risk criterion set forth in 40 CFR 162.11 (a)(3)(ii)(A).

As noted in Section II.B.4, creosote is a complex mixture of organic chemicals; of particular importance toxicologically are the polynuclear aromatic hydrocarbons (PAH's), aromatic amines, and phenolic constituents. Different creosote samples can be expected to contain varying proportions of these three and other broad classes of chemicals (see Table II.B-7).

A qualitative case can be made for dermal exposure to whole creosote. However, workers inhaling airborne creosote may be exposed to somewhat different proportions of creosote components. The variable nature of the creosote to which workers are exposed and the qualitative nature of the exposure information available to the Agency does not permit the development of a quantitative risk assessment for mutagenicity. In addition, the mutagenicity results available for creosote and its components are limited to in vitro data which do not allow the quantitative assessment of risk (FR 45:221, Oct. 30, 1980). Therefore, the Agency has proceeded on the basis of a qualitative assessment of mutagenic risk.

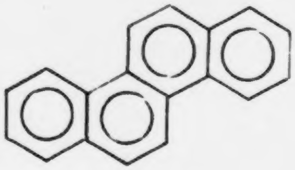
The Agency's proposed guidelines for mutagenicity risk assessments (FR 45:221, October 30, 1980) define a mutagen as "a chemical substance or mixture of substances that can induce alterations in the DNA of either somatic or germinal cells of organisms." This section summarizes evidence for mutagenicity of creosote and its chemical components and discusses the implications of these results for risk of intrinsic (somatic) and heritable (germinal) mutagenicity.

As summarized above, creosote causes mutagenic effects in cell cultures (e.g., Salmonella test systems, mouse lymphoma cells,

TABLE II.B-7

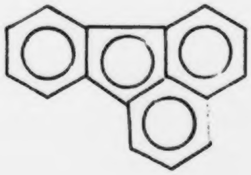
Classification of Chemicals in Creosote*

1. Unsubstituted 6-membered aromatic ring systems (fused, unfused or mixed)



Compound	Effect	References
chrysene	mutagenic initiator	a,b,c,d,e f
pyrene	co-carcinogen (with fluoranthene) mutagenic	 f b
benzo[a]pyrene	mutagenic carcinogenic	a,b,c,d,n,o g
benzo[a]anthracene	mutagenic carcinogenic	a,b,c g,h
naphthalene	inhibitor	i
anthracene	mutagenic	j
acenaphthene	mutagenic	j

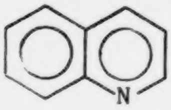
2. Unsubstituted aromatic ring systems containing 5-numbered rings



flouranthene	co-carcinogenic	f
benz[j]fluoranthene	carcinogenic	g

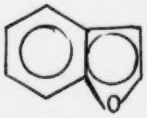
TABLE II.B-7 (Continued)

3. Heterocyclic Nitrogen bases

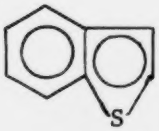


quinoline	carcinogenic	d
benzocarbazoles	carcinogenic	h
1-methyl isoquinoline	possibly carcinogenic	d
3-methyl isoquinoline	"	"
5-methyl quinoline	"	"
4-methyl quinoline	"	"
6-methyl quinoline	"	"
5-methyl isoquinoline	"	"
7-methyl isoquinoline	"	"
6-methyl isoquinoline	"	"
1,3-dimethyl isoquinoline	"	"

4. Heterocyclic Oxygen and Sulfur compounds



coumarone



thionaphthene

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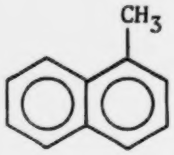
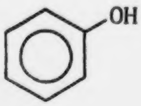
TABLE II.B-7 (Continued)

5. Alkyl substituted compounds



methyl fluoranthene	possibly carcinogenic	d
1-methyl naphthalene	inhibitor	i
2-methyl naphthalene	"	"
ethyl naphthalene	"	"
2,6-dimethyl naphthalene	"	"
1,5-dimethyl naphthalene	"	"
2,3-dimethyl naphthalene	accelerator	"
2,3,5-trimethyl naphthalene	inhibitor	"
2,3,6-trimethyl naphthalene	accelerator	"
methyl chrysene	initiator	p,q

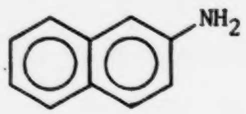
6. Hydroxy compounds



phenol	promoter	f,m
p-cresol	promoter	m
o-cresol	"	"
m-cresol	"	"

TABLE II.B-7 (Continued)

7. Aromatic amines



2-naphthylamine	carcinogenic	l
p-toluidine	"	m
o-toluidine	"	"
2,4-xylidine	"	"
2,5-xylidine	"	"

8. Paraffins and naphthenes

$$\left[\ \text{-CH}_2\text{-}\ \right]_n$$ (n is large, e.g., greater than 15)

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* Classes taken from McNeil (1952).
a. McCann *et al*. (1975)
b. Thilly and Liber (1979)
c. Nagao and Sugimura (1978)
d. Hollstein *et al*. (1979)
e. Sivak (1979)
f. Van Duuren (1976)
g. IARC (1973)
h. CAG (1978b)
i. Schmeltz *et al*. (1978)
j. Epler *et al*. (1979)
k. Boutwell and Bosch (1959)
l. IARC (1974)
m. Weisburger *et al*. (1978)
n. Wyrobek and Bruce (1975)
o. Epstein *et al*. (1972)
p. Van Duuren (1966)
q. Van Duuren and Goldschmidt (1976)

and human lung cells. The conclusion that creosote is a potential human mutagen is further supported by data from the scientific literature. Some components of creosote give positive results in the S. typhimurium (Ames) test when assayed individually: anthracene (Epler et al. , 1979), benzo[a]pyrene (McCann et al., 1975; Thilly et al., 1979; Hollstein et al., 1979; Nagao and Sugimura, 1978), chrysene (McCann et al., 1975; Thilly et al., 1979; Nagao and Sugimura, 1978) acenaphthene (Epler et al., 1979), and benz[a]anthracene (McCann et al., 1975, Thilly et al., 1979; Nagao and Sugimura, 1978). Phenanthrene, pyrene, naphthalene, and fluorene were negative in the Ames test. However, pyrene was positive in the S. typhimurium forward mutation system (Thilly and Liber, 1979).

Cell culture test systems using host cells other than S. typhimurium also lend credence to the finding that individual creosote components have the capacity to induce damage to DNA. Hollstein et al. (1979) and Sivak (1979) demonstrated that the following creosote components were positive in cell culture test systems: benzo[a]pyrene (baby hamster kidney, mouse C3H 10T1/2, mouse BALB 3T3, hamster lung V-79 cells, Syrian hamster embryo, and rat embryo), benz[a]anthracene (virus-infected rat embryo, Syrian hamster embryo), chrysene (in vivo sister chromatid exchange, hamster embryo, virus-infected rat embryo). Chrysene, phenanthrene, and pyrene were not mutagenic for V-79 cells.

In a recent study, Mortelmans and Riccio (1980) used the E. coli WP2 system to test several coal tar products (e.g., flaked coal tar pitch and some components of coal tar epoxy) for mutagenicity. All these products elicited a reproducible, dose-dependent mutagenic response, but only in the presence of metabolic activation.

The interactions in a mixture of different chemical mutagens may be such as to potentiate, inhibit, or have no effect (depending on the chemicals involved) on the mutagenic activity of the mixture (Saffiotti _et al_., 1979a, 1979b; Schmeltz _et al_., 1978; see also Section II.B.6.b.v). In the case of creosote, mutagenic potency is difficult to quantify in test systems due to the complexity of this particular mixture of chemicals. Some creosote components are mutagenic, while others are not; some are also cytotoxic. A mixture of these chemicals will, in addition to being cytotoxic, compete for metabolic processes. This is particularly important in this instance since creosote apparently requires metabolic activation for mutagenic activity in test systems. Consequently, different batches of creosote and creosote/coal tar blends may have different mutagenic potencies.

In summary, direct evidence exists that creosote and many of its component chemicals give positive test results in the Ames test. Data from other _in vivo_ mutagenic test systems for creosote and its purified components support these positive results and the presumption of somatic mutagenicity.

Whether or not creosote actually reaches the germinal cells of intact mammals is unknown to the Agency. The only evidence that the Agency has that it does is restricted to benzo[a]pyrene. Wyrobek and Bruce (1975) found that intraperitoneal injections of benzo[a]pyrene caused abnormalties in sperm morphology in (C57BL x C3H)F_1 mice. Benzo[a]pyrene caused an excess incidence of dominant lethal mutations in ICR/Ha Swiss mice (Epstein et al., 1972). Although Russell and Russell (1978) found benzo[a]pyrene to be negative for mutagenicity in the mouse specific locus test, a positive response was obtained in both the mouse dominant lethal test and the X-chromosome loss test. Positive results in either of these latter two tests indicate heritable mutagenic effects. The Agency does not have any evidence that the other constituents of creosote do not reach the germinal cells.

In conclusion, the exposure data indicate that applicators of creosote and creosote/coal tar wood preservatives are subject to both dermal and inhalation exposure during the application process and that other individuals who handle or come in contact with creosote-treated products may likewise experience dermal and inhalation exposure. About 4,500 workers are involved in commercial pressure treatment with creosote. The Agency has determined that the application of creosote wood preservatives and the use of creosote-containing products poses a significant, although currently unquantifiable,risk of mutagenicity to the human population.

6. Qualitative Risk Assessment for Oncogenicity

a. Introduction

Creosote and many of its component chemicals have been well characterized as carcinogens in studies with laboratory animals (see Table II.B-1). These studies, along with the several reports in the literature of skin cancer in people exposed to creosote, suggest that creosote is a human carcinogen (CAG, 1977), even though no well-conducted epidemiology studies of workers using creosote have been performed.

Although we know that whole creosote is a carcinogen, we have no definitive data on the identity of airborne chemicals to which workers are exposed in wood treatment plants where creosote is used. Moreover, despite the reports of creosote burns in workers, we have no quantitative data on dermal exposure to these workers. The laboratory animal assays and the human case studies substantiate the potential for oncogenic hazard to workers engaged in treating wood with creosote. However, the lack of 1) precise human exposure data, and 2) knowledge of the identity and quantity of airborne chemicals preclude quantitative assessment of risk of carcinogenicity in humans.

Although creosote contains several known carcinogens, it also contains an array of chemicals which may act as initiators, promotors, inhibitors, and co-carcinogens. These agents all affect the carcinogenic potential of creosote. Because of synergism among these components, the carcinogenic potency of creosote cannot be predicted by assaying samples of the mixture for single carcinogenic components. Early attempts to correlate carcinogenic potency with quantitative analytical determinations of individual carcinogens in creosote (Lijinsky *et al.*, 1957) and petrochemical fractions (Bingham *et al.*, 1980) have been unsuccessful. Therefore, this section will review the qualitative evidence for carcinogenic risk.

b. Chemical Composition of Creosote and Creosote/Coal Tar Blends

As noted in Section II.B.4, creosote is a complex mixture of organic chemicals produced as a by-product of coking. The coke oven volatiles are condensed primarily as water and coal tar, the latter a mixture of liquid and solid hydrocarbons. Distillation separates creosote from coal tar.

i. Creosote

The chemicals comprising creosote have been characterized by McNeil (1952) into eight classes. We present these classes here because they are of interest toxicologically (Table II.B.7). Those derived from coal mined from different sources can vary in the relative proportions of chemicals present. However, McNeil emphasizes that all creosotes contain essentially the same classes of chemical compounds, even while the proportion and distribution of classes varies.

ii. Coal Tar

As discussed in Section II.B.4, coal tar is often blended with creosote for wood preservative processes. Coal tar comprises the entire spectrum of non-aqueous coke oven volatiles. Because the condensate extends to boiling regions higher than those of the creosote fractions, coal tar contains a large number of 5- and 6-ring polynuclear aromatic hydrocarbans (PAH's). The carcinogenicity of many of these larger PAH's has been studied and reviewed extensively (CAG, 1978b; IARC, 1973). Known PAH carcinogens in coal tar are benz[a]anthracene, benz[a]carbazole, benzo[b]fluoranthene, benzo[i]fluoranthene, benz[c]acridine, benzo[a]pyrene, benzo[e]pyrene, chrysene, dibenz[a,i]anthracene, dibenz[a,h]anthracene, dibenzo[a,h]pyrene, dibenzo[a,i]pyrene, and indeno[1,2,3-cd]pyrene.

c. Toxicology

Creosote, coal tar, and many of the individual chemicals comprising these mixtures have been subjected to animal carcinogenesis assays and short term mutagenesis assays in the laboratory. In addition, because of the presence of co-carcinogens as well as individual carcinogens in creosote and coal tar, these mixtures have been examined for synergism among their components (Schmeltz *et al*., 1978; Van Duuren, 1966). Van Duuren (1966) reviews the phenomena of two-stage carcinogenesis and co-carcinogenesis in animals and humans. The carcinogenicity of creosote, coal tar, and certain of their component chemicals has been reviewed by the IARC (1973) and EPA (CAG 1977, 1978a, 1978b).

i. Creosote

The CAG report (1977) summarizes several mouse skin painting studies (Woodhouse, 1950; Poel and Kramer, 1957; Lijinsky *et al.*, 1957; Boutwell and Bosch, 1958) in which creosote was found to cause skin papillomas and carcinomas. In one study (Roe *et al.*, 1958), lung adenomas were observed as well as skin tumors in mice receiving dermal applications of creosote oil. The CAG report also cites a number of case studies showing skin cancer in creosote workers. Typically, premalignant lesions and malignant tumors appeared on the skin of the face, hands, forearms, and scrotum. Although no adequate epidemiological studies have been performed on creosote workers, the CAG report cites these case studies as suggesting that creosote is a human carcinogen.

ii. Coal Tar

Two hundred years ago, scrotal cancer was observed in English chimney sweeps (Pott, 1775). Since that time, several reports have confirmed cases of cancer in humans resulting from industrial exposure to coal tars (NIOSH, 1977). EPA (CAG, 1978b) has reviewed a mortality study of 5,788 roofers (Hammond, *et al.*, 1976). These workers used pitch and asphalt, both of which contain benzo[a]pyrene. Alhough smoking histories of these workers were not available, measurements of typical worksite concentrations of benzo[a]pyrene enabled the authors to conclude that occupational exposure to this chemical was at least 100 times greater than the exposure expected from smoking alone. Mortality figures for workers with 20 or more years of membership in the roofing union show deaths in excess of those expected from cancer of the lung, gastrointestinal tract, urinary bladder, and skin.

The CAG report also summarizes numerous skin painting studies in which coal tars produced skin cancer in mice and rabbits. In addition, tumors of the lung were reported in mice inhaling coal tar aerosols (Horton *et al*., 1963). The scientific literature also contains numerous studies of the carcinogenicity of individual PAH's in coal tar. Comprehensive reviews of many of these PAH's appear in the IARC (1973) reviews.

iii. Coal Tar Neutral Oils

Coal tar neutral oils have been shown to be oncogenic in laboratory animals. For example, Berenblum and Schoental (1947) tested several coal tar neutral oil fractions in mice and rabbits. Most fractions were found to be oncogenic. In 1961, Horton showed that extracts (in maleic anhydride) of coal tar neutral oils produced tumors in mice in about 33 weeks. Earlier, however, Cabot *et al*. (1940) applied benzene solutions of benzo[a]pyrene with and without coal tar nuetral oil to the skin of albino mice. The coal tar neutral oil was found to inhibit the tumorigenic response of benzo[a]pyrene.

iv. Coke Oven Emissions

Substantial epidemiological evidence is available to show that exposure to coke oven emissions gives rise in workers to an excess risk of death from lung cancer and cancers of the bladder, prostate, pancreas, and large intestine (CAG, 1978a). As noted earlier, the airborne chemicals comprising coke oven emissions are condensed to form coal tars. The CAG report emphasizes that studies of risk to coke oven workers cannot be used directly to predict the risk from cancer to wood workers. This is due to the fact that coke oven emissions are produced at significantly higher temperatures than those used to heat creosote and creosote/coal tar blends in wood preservative treatment plants. Therefore, coke oven emissions are more likely to contain carcinogenic substances, particularly high boiling PAH's, than those to which wood preservative workers are exposed. Thus, any risk estimates based on coke oven studies would have to be considered as providing only upper limits for risks to wood preservative workers exposed to creosote and creosote/coal tar.

v. Carcinogenicity of Individual Chemical Components of Creosote

A series of aromatic amines, among them some monocyclic amines occurring in creosote (Nestler, 1974), were tested for long-term toxicity by dietary administration to Charles River rats and HaM/ICR mice (Weisburger et al., 1978). Of these amines, ortho- and para-toluidine, 2,4,-xylidine and 2,5,-xylidine led to tumors in various tissues. Meta-toluidine had questionable activity. The boiling points of these compounds range from 200°C to 215°C. Chrysene, one of the major components of creosote, is a 4-ring PAH which boils at 448°C. As reviewed by the IARC (1973), chrysene causes skin tumors in mice. In addition, it acts as an initiator of skin cancer in mice. (The oncogenicity of chrysene is presently under review by EPA's Carcinogen Assessment Group.)

A number of chemicals in creosote act as co-carcinogens, accelerating agents, and inhibitors. Among these are cresols, which occur as ortho-, para-, and meta-isomers in creosote. In 1959, Boutwell and Bosch reported that cresols administered in benzene twice weekly to the skin of mice acted as promotors of the carcinogenic response initiated by dimethylbenzanthracene. No tumors were found in the solvent control group. Boutwell and Bosch also report that phenol, another chemical in creosote, acts as a tumor-promoting agent. Pyrene and fluoranthene, two major components of creosote which are not carcinogenic by themselves, have been shown to be co-carcinogenic when applied on mouse skin together and with a low dose of benzo[a]pyrene (Hoffmann and Wynder, 1963).

Schmeltz et al. (1978) tested the co-carcinogenicity of naphthalene and alkylated naphthalenes, other major components of creosote. The chemicals were applied with benzo[a]pyrene to mouse skin. These investigators confirmed the inhibiting effects of naphthalene, methylnaphthalene, ethylnaphthalene, 2,3,5-trimethylnaphthalene, 2,6-dimethylnaphthalene, and 1,5,-dimethylnaphthalene. On the other hand, 2,3-dimethylnaphthalene and 2,3,6-trimethylnaphthalene were found to be accelerators. These investigators correlated their bioassay results with incubations of the naphthalene derivatives and benzo[a]pyrene in hepatic mixed function oxidase systems. When the yield of benzo[a]pyrene metabolites upon co-incubation was measured, it was found that the inhibitors of carcinogenesis also retarded the progress of benzo[a]pyrene metabolism; conversely, the accelerators of carcinogenesis led to enhanced yields of benzo[a]pyrene metabolites.

d. Conclusion

In addition to the fact that creosote is well-characterized as an animal carcinogen, the several individual case studies provide strong evidence of its potential as a human carcinogen. Along with the case for oncogenicity of whole creosote, many of the individual chemicals in creosote have been shown to be carcinogens.

Exposure to creosote in wood treatment plants can occur dermally or by inhalation. Although we have no quantitative data regarding the extent of dermal exposure in these workers, the large number of reports of creosote burns in the literature demonstrates that this route of exposure exists.

Inhalation exposure to creosote can occur in a variety of ways. Measured values of benzene-soluble polycyclic particulate organic matter (PPOM), as well as confirmation of specific constituents in the breathing zones of workers, bears this out. In some pressure treatment processes, creosote is blended with coal tar, which has a high proportion of 5- and 6-ring PAH carcinogens. In these treatment plants, the greatest inhalation exposure may occur when the cylinder door is opened and tram cars are removed from the chamber. Air turbulence may result in suspension of particulate material as well as creosote vapors. One analysis (see Table II.B-2) identified chemicals with two to four rings and boiling points ranging from 218^{o}C to 393^{o}C.

Although we do not have precise data as to the profile of airborne constituents of creosote to which treatment plant workers are exposed, airborne chemicals which have been confirmed span a boiling point range matched by that of many of the carcinogens and co-carcinogens in creosote and creosote/coal tar. The heavier PAH's, such as chrysene or the 5- and 6-ring PAH carcinogens, may be less concentrated in the air than in whole creosote. Other carcinogenic components, such as aromatic amines which have lower boiling points, may be more concentrated in airborne (vapor) phases than in whole creosote. The Agency believes this supports the presumption of carcinogenic risk to workers inhaling creosote vapors.

In addition to the variable nature of creosote and creosote/coal tar blends, the complex nature of the material and the toxicological synergism of its constituents preclude the use of a single component chemical as an index of exposure for use in a quantitative risk assessment. Moreover, without a well-executed epidemiological study of creosote treatment plant workers or without animal inhalation data along with treatment plant exposure data, we have no model for estimating the preservative's carcinogenic potency. The data on excess deaths from cancer of coking oven workers are not directly applicable to the situation for wood preservative workers. This is because the temperatures of coking ovens are much higher than those to which creosote and its blends are subjected in wood treatment plants, giving rise, in all probability, to an entirely different profile of airborne chemicals.

It is clear from the large number of laboratory studies on whole creosote and its individual components that creosote is an animal carcinogen. This, along with the realization that some finite, though presently unquantifiable, exposure to applicators exists, causes the Agency to have significant concern regarding the risks to these applicators.

C. Inorganic Arsenicals

1. Analysis of Rebuttal Comments Concerning Interconversion of Pentavalent to Trivalent Arsenic

a. Basis of Concern

i. Introduction

There are two forms, or valence states, of the inorganic arsenical compounds, trivalent and pentavalent. It has long been recognized that trivalent arsenic is the more acutely toxic of the two forms. It binds to tissue more readily and inhibits the action of many enzymes. Pentavalent arsenic is less acutely toxic than the trivalent form and is the predominant form found in mammalian (or aerobic) systems.

Interconversion is defined as the oxidation of the more toxic trivalent arsenic to the less toxic pentavalent form, and the reduction of the pentavalent form of arsenic to the trivalent form. The interconversion concern addresses the chemical conversion (in mammalian systems) of pentavalent arsenic, the less toxic form, to trivalent arsenic, the more toxic form. Oxidation is the favored reaction in aerobic (mammalian) systems and reduction is the favored reaction in anaerobic systems. Because of the differences in the forms' chronic and acute toxicity, interconversion is important in evaluating the environmental and health effects of the inorganic arsenical compounds.

The problem of interconversion is addressed by EPA under Section 162.3(L) and (J) of FIFRA's Rules and Regulations, which define the meaning of "degradation product" as a substance from any transformation of a pesticide. The implication of the interconversion issue and the Agency's definition of degradation product is that if interconversion is shown to exist, both valence forms of arsenic can be regulated as one compound, trivalent arsenic.

ii. Studies

Two studies form the basis of the Agency's concern that pentavalent arsenic (arsenate) can be reduced in mammalian systems to trivalent arsenic (arsenite). Ginsberg (1965) measured arsenite in dog kidneys infused with arsenate; Lanz _et al_. (1950) measured the urinary excretion of arsenite in rats after injecting them with arsenate.

Four studies have shown that similar toxic effects of arsenite and arsenate occured in four separate biological systems. However in each case arsenite was from two to five times more potent. The studies were an acute toxicity rat study (Franke and Moxon, 1936), a teratology study in Swiss Webster mice (Hood, 1972), and a chronic feeding study in rats (Byron _et al_., 1967) and dogs (Byron _et al_., 1967) which showed a marked enlargement of the common bile duct, weight loss, and high mortality.

Another study indicated that there was a type of equilibrium concentration ratio between arsenite and arsenate of four to one in wine fermentation systems and in commercial wines (Crecelius 1977a).

The study suggests that an equilibrium concentration between arsenate and arsenite exists in living systems.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: Interconversion of arsenate to arsenite *in vivo* (1, 2, 156, 165)

Several rebutters state that the references relied upon as direct evidence of *in vivo* conversion of arsenate to arsenite are inadequate. Recent work reporting the presence of methylated organic arsenicals in plasma and urine lead to the conclusion that Ginsburg was (inadvertently) determining and reporting pentavalent organic arsenicals and not *in vivo* interconversion of pentavalent to trivalent arsenic. Further, there is not an equilibrium ratio of arsenate to arsenite in living organisms. While evidence is strong that arsenite is converted to arsenate *in vivo*, pentavalent arsenic does not reduce to trivalent arsenic *in vivo*

Agency Response: The Agency agrees with the rebutters that the analytical methodology in the studies used in Position Document #1 (PD-1) to provide direct evidence of interconversion contained deficiencies. Position Document #1 (pp. 72-73) acknowledges that the predominant form of arsenic (organic and inorganic) in mammals is pentavalent, and that when trivalent arsenite is administered it is oxidized to the less toxic pentavalent form which is the favored reaction. The Position Document also concluded that oxidation of trivalent arsenic to pentavalent arsenic has often been described in the literature. Conversion of pentavalent arsenic to trivalent arsenic, on the other hand, has been shown to occur under anaerobic conditions by Creselius (1977a) (in fermenting wine) and Ferguson and Gavis (1972) (in oxygen deficient waters). However, the mammalian body is primarily an oxidizing environment. The primary sources of evidence which support the mammalian conversion of pentavalent arsenic to trivalent arsenic are the studies by Ginsburg and Lotspeich (1963) and Ginsberg (1965). These studies which determine the valence state of arsenic by the method of Crawford and Storey (1944), contend that pentavalent arsenic is converted in the mammalian body to trivalent arsenic. The Agency has determined that the method used in the Ginsburg studies is valid in the absence of organic arsenic (see comment by Lombardini, page 80 of PD-1). However, when the method is applied to biological fluids which may contain organic arsenic a preliminary extraction step with carbon tetrachloride must be performed to remove the organic arsenic.

Although the studies by Ginsburg used the method of Crawford and Storey it was not stated specifically that the carbon tetrachloride extraction procedure was performed.

The Crawford and Storey procedure relies on the reaction of inorganic arsenite with sodium ethyl xanthate under acid conditions, followed by extraction of the product with carbon tetrachloride. Arsenate does not react and remains in the aqueous layer; hence, trivalent arsenic and pentavalent arsenic valence states can be separated by this procedure. As discussed above, Ginsburg made no mention of a preliminary extraction step in his studies. Therefore it appears that organic arsenicals could have interfered with the analytical procedure and been interpreted as trivalent arsenic. It has been shown recently that dimethylarsinic acid (DMAA), a pentavalent species, is a major metabolite in mammals, including man (Braman and Foreback, 1973; Creselius, 1977b; Smith et al., 1977; Tam et al., 1978; Charbonneau et al., 1979). DMAA reportedly is not soluble in carbon tetrachloride, and therefore not extracted by, carbon tetrachloride, but will react with sodium ethyl xanthate to form trivalent organic arsenicals which are soluble in carbon tetrachloride (Zingaro, 1979). Zingaro also pointed out that sodium ethyl xanthate, under the acid conditions used, can function as a reducing agent and transform inorganic pentavalent arsenic to trivalent arsenic. Thus it appears reasonable to conclude that the analytical technique used by Ginsburg probably did not differentiate between the valence states of arsenic encountered in his experiments. The Lombardini commentary cited in PD-1 (page 80) did not address the issue of the inadequacies of the analytical technique.

Peoples (1964) developed a modified procedure to circumvent the difficulties discussed above. In his procedure, an alkaline pH was used for the reaction with xanthate, followed by the carbon tetrachloride extraction. The trivalent arsenic is removed in the extraction, leaving pentavalent arsenic in the basic aqueous fraction.

Peoples reported that, in two cows fed arsenic acid (pentavalent arsenic), all the arsenic was in the pentavalent state. He found no evidence that arsenic acid is partially reduced to the trivalent form. It should be noted that the study by Peoples used arsenic acid administered in the feed, compared to the intravenous technique used by Ginsberg. However, Tam _et_ _al_. (1978) also used intravenous administration of arsenic acid, and found about 90% of the arsenic present in the urine as DMAA after three days; DMAA was the dominant species in plasma two hours after dosing. Similar results were found by Charbonneau _et_ _al_. (1979).

Other references cited in support of the _in_ _vivo_ interconversion of arsenate to arsenite may also have methodology problems. The study by Land _et_ _al_. (1950) appears to be deficient in both sample preparation and analysis procedures. Also, in the study by Mealey _et_ _al_. (1959), the arsenate/arsenite ratio may have been caused by a reducing environment in the analytical procedure.

The conclusions of the studies by Peoples (1964) and Lakso and Peoples (1975) contradict the contention of in vivo conversion of arsenate to arsenite. Peoples (1964) fed arsenic acid to cattle and found all the arsenic in the pentavalent form; he concluded that "there is no evidence that it is partially reduced to the trivalent form." Lakso and Peoples (1975) found that both cattle and dogs produced methylated arsenic when fed either inorganic arsenate or arsenite. They suggested that arsenite may be oxidized to arsenate before biomethylation, due to the rapid appearance of methylated arsenic after arsenite feeding.

In a brief experiment designed to test the theory that DMAA would have been recovered and measured as trivalent arsenic, Osmose Wood Preserving Company carried out the Crawford and Storey analytical procedure exactly as described, but used DMAA (99.93% pure) instead of arsenic acid. After reaction with sodium ethyl xanthate and extraction with carbon tetrachloride, they recovered up to 92% of the DMAA in the organic solvent fraction. Thus DMAA would have been mistaken for trivalent arsenic by this procedure. Several repetitions of this experiment led to generally lower recoveries of DMAA (less than 25%); nevertheless it now seems clear that DMAA, when present in biological fluids, is capable of giving a false positive reaction for trivalent arsenic when the analytical procedure of Crawford and Storey is used.

c. Summary of Rebuttal Comments Concerning Interconversion: Conclusion

The Agency agrees with the rebutters that the preponderance of chemical evidence on the issue of interconversion of arsenic species in mammalian systems demonstrates the following:

1. Conversion of arsenite to arsenate is the dominant pathway in vivo. No substantial evidence was submitted, however, which indicated that there is not an equilibrium concentration ratio (however small) between arsenate and arsenite in oxidizing systems.

2. Biomethylation of arsenic species in mammalian systems can lead to the formation of dimethylarsinic acid (DMAA).

3. DMAA has the potential to interfere in the Crawford and Storey analytical procedure, leading to possible false positive determinations of arsenite.

The Agency therefore concludes that, due to uncertainties in the analytical methodology, the reduction of pentavalent arsenic to trivalent arsenic in vivo has not been demonstrated with sufficient experimental evidence to be given weight in the arsenic risk assessment at this time. However, at the same time the possibility of the interconversion reaction taking place has not been ruled out.

2. Analysis of Rebuttal Comments Concerning Oncogenicity

a. Basis of Presumption

i. Introduction

The Agency has relied primarily on human epidemiology studies to assess the oncogenicity of the inorganic arsenical compounds. Epidemiological studies in conjunction with confirmatory animal tests provide the best evidence that an agent is a human carcinogen. Albert et al. (1977) noted that "of the chemical agents that are generally accepted to have produced human cancer, all but one (arsenic), produced an oncogenic response in rats and/or mice...in the same organ as in humans when tested by the appropriate route of exposure." Arsenic is unique in this respect (Frost, 1967; NAS, 1977b) as suitable animal models are not available for extrapolation of oncogenic responses to humans.

Chronic exposure to arsenic, either both forms (tri- and pentavalent) together or singly, or an unspecified form, has produced abnormal pigmentation, keratosis, skin cancer, and lung cancer, as well as cancer of the liver and perhaps cancer in other organs and sites. Trivalent inorganic arsenic was the predominant form in most exposure situations. Pentavalent inorganic arsenic was the predominant form in two exposure situations where increased lung cancer was observed; these were exposure during pesticide manufacturing and chronic exposure of orchard workers to lead arsenate.

ii. Studies

Three comprehensive reviews by Neubauer (1947), Stellman and Kabut (1978), and the National Academy of Sciences (1977) documented the occurrence of skin cancer in patients treated with Fowlers Solution (potassium arsenite). Yeh et al. (1968), Yeh (1963), Yeh (1973), Tseng et al. (1968), and Tseng (1977) described chronic arsenic poisoning and skin cancer resulting from arsenic contaminated drinking water in Taiwan. Osburn (1969) described chronic arsenic poisoning and lung cancer in patients exposed to arsenic containing mine dust.

Bergoglio (1964), and Neubauer (1947), described skin cancers and other disorders in Argentine and Silesian villagers exposed to arsenic contaminated groundwater. Pinto and Bennett (1963), Lee and Fraumeni (1969), Milham and Strong (1974), and Pinto et al. (1977) in the United States and Kuratsune et al. (1974) and Tokudome and Kuratsune (1976) in Japan documented increased incidence of lung cancer among smelter workers exposed to arsenic trioxide. As in most epidemiology studies, the workers were exposed to more than one chemical agent. The consistency of the findings, however, left little doubt that arsenic trioxide was at least a major contributor to the incidence of lung cancer in heavily exposed workers.

Hill and Fanning (1948) reported skin, lung, and liver cancer in pesticide factory workers exposed to sodium arsenite. Ott (1974) reported lung cancer in pesticide manufacturing plant workers exposed to calcium and lead arsenate. Roth (1956, 1957a, 1957b, 1957c, 1958), Denk (1969), Thiers (1967), Braun (1958), Von Pein (1943), Galey et al. (1963), and Petres (1957), reported skin, lung and liver cancers associated with the use of calcium arsenate and copper acetoarsenite by German and French vineyard workers. Finally, NIOSH (1975) re-examined mortality statistics in apple orchard workers exposed to lead arsenate and found statistically significant increases in respiratory cancer.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: No Animal Studies (1, 165, 188, 213,)

Several rebutters state that no suitable animal experiments have been performed with exposures to known arsenic compounds to support the epidemiology studies, which allegedly show that inorganic arsenic is a human carcinogen.

Agency Response: At the time PD-1 was written the comment was largely true. No animal skin cancer models had been developed showing the skin changes observed in human chronic arsenical poisoning. Animals had not been adequately tested via inhalation. Only one study (Oswald and Goertler, 1971) resulted in a positive tumor response but the experiment was inadequate to establish arsenic as a carcinogen for several reasons: a) it was designed as a fetal toxicity study, b) the tumor type was not well described (the single word, "leukoses," translated from

German was used), and c) the agent given was only described as a sodium salt of arsenic.

However, the Agency has taken the position that human exposures to an agent which results in a carcinogenic response constitutes firm evidence that a human hazard exists whenever people are exposed. When such evidence exists, as it certainly does for arsenic, the value of confirmatory animal studies is that the specific compound causing the response can be identified. When this confirmatory animal evidence is lacking, as it was when the PD-1 was written, the Agency critically examines the exposure evidence for each of the available epidemiology studies. As discussed below in comment 2 the Agency reached a conclusion that the most likely cause for the responses was inorgnic arsenic.

The recent study by Ivankovic et al. (1979) in rats has largely, but not completely, confirmed that inorganic arsenic is the agent responsible for the orcogenic response. The authors found lung carcinomas after intratracheal installation of a mixture of calcium arsenate, calcium oxide, and copper sulfate. This mixture is an arsenical pesticide preparation used in some German vineyards during the 1930's. This experiment strongly indicates that pentavalent arsenic can induce lung carcinomas, although the contribution of sulfate, copper, and calcium oxide cannot be ruled out until further experiments are carried out.

Therefore, the comment as stated is still true, i.e., there are no animal experiments which show unequivocally that inorganic arsenic is the agent responsible for the lung and skin cancers that have been observed repeatedly with high human arsenic exposure. However, the epidemiology evidence as summarized does indicate that a human hazard exists and the Agency position that inorganic arsenic is the most probable causative agent remains unchanged.

Rebuttal Comment 2: Uncertainties in the Interpretation of Epidemiology Studies (1, 2, 145, 165, 166, 188, 213)

A number of rebutters state that several uncertainties in the interpretation of any epidemiologic study make it difficult for the Agency to claim that inorganic arsenicals, and specifically pentavalent arsenic, is responsible for the increased incidence of cancer observed. These factors include a) the difficulty of estimating retrospectively the amount and duration of exposures for each person in the cohort, b) difficulties in sorting out other chemical agents, environmental factors and personal habits which could influence the death rates and causes of death observed in the studies. In the smelter studies the SO_2 usually present along with arsenic is a contributing factor which may be more important than arsenic.

Agency Response: As pointed out in the PD-1, the epidemiological data is very clear that chronic exposure to arsenic in various situations has resulted in symptoms of abnormal skin pigmentation, keratosis of the skin, squamous cell carcinoma and basal cell epitheliomas of the skin as well as bronchial carcinoma and liver angiosarcoma. This overall conclusion remains valid despite the uncertainties in each individual study.

Trivalent arsenic was known or suspected to be present in all of these situations with the one exception that in the Ott _et al_. (1974) study the arsenic was predominately pentavalent. In all of the smelter studies SO_2 accompanied trivalent arsenic exposures but in the sheep dip situation, (Hill and Fanning, 1948), both lung and skin cancer were observed with no SO_2 exposure. The latter study indicates that arsenic without SO_2 exposure can induce lung cancer. When the risk of air exposures were analyzed quantitatively, (CAG, 1980) it was found that the Ott _et al_. (1974) study which was predominately pentavalent arsenic, had a lung cancer risk which was indistinguishable from the risk in the smelter studies, where trivalent arsenic and SO_2 were present. This comparison indicates that inhaled pentavalent and trivalent arsenic do not differ appreciably in their effectiveness in causing lung cancer.

Therefore, although the evidence is not unequivocal, the predominate theme which is consistant with all of the evidence is that exposure to trivalent arsenic without SO_2 can induce lung and skin cancer when inhaled and skin cancer when ingested. The same can be said for pentavalent arsenic except that epidemiologic evidence of cancer caused by ingested pentavalent arsenic does not exist.

Rebuttal Comment 3: No Direct Evidence that Pentavalent Arsenic Is an Oncogen (12, 39, 156, 165, 166)

Several rebutters state that The Agency does not present convincing biochemical or toxicologic evidence that arsenic in the pentavalent form is carcinogenic. Although it is known that trivalent arsenic reacts with sulfhydryl (SH) groups on proteins and binds to enzymes no such evidence exists for pentavalent arsenic. Furthermore, there is no direct evidence that pentavalent arsenic is converted to trivalent arsenic in the body.

Agency Response: In the PD-1 the Agency had the difficult task of evaluating the hazard to pentavalent inorganic arsenic, a compound which has not been evaluated well toxicologically. Indirect, but plausable, arguments were made which suggested that pentavalent arsenic might exert its toxic action via a trivalent arsenic intermediate state. Several urinary excretion studies which purportedly show that arsenic is mainly in the trivalent state after pentavalent arsenic is administered were likely carried out without proper precautions to prevent oxidation after the samples were collected. No further information was presented in the rebuttal comments on the results of direct experiments designed to test the possibility of conversion of pentavalent to trivalent arsenic.

Therefore, the Agency finds the rebuttal comments correct in stating that there is no direct toxicological or biochemical evidence for the toxicity of pentavalent arsenic or the conversion of pentavalent to the toxic trivalent form. However, this does not rebut PD-1 position, since the PD-1 stated that there is ample indirect evidence to suggest beyond a reasonable doubt that pentavalent arsenic has the same toxic effects astrivalent arsenic but is less effective quantitatively.

Rebuttal Comment 4: Arsenic Is a Naturally Occuring Element (134)

Bonide Chemical Co. Inc., states that the natural and ubiquitous occurence of arsenic in food such as sea foods, and in drinking water and soils of some regions already causes a large exposure of people to arsenic. Any attempt to reduce exposure via regulation of arsenic products would have an insignificant effect on total exposure.

Agency Response: The Agency agrees that the largest single source of exposure to arsenic is from food where it predominately occurs as organically bound arsenic, which is generally recognized as non-toxic due to its metabolic pathway. However, the exposure to the inorganic arsenicals alone in the groups of people and exposure situations identified in the exposure assessment document (see section II.C.7 of this document) could be substantially reduced by the regulation of inorganic arsenic as a wood preservative.

c. Summary of Rebuttal Comments Concerning Oncogenicity: Conclusion

In summary, the Agency concludes that chronic exposure to either trivalent or pentavalent arsenic can induce cancer and that the risk criteria for oncogenicity of inorganic arsenicals as stated in PD-1 remains unrebutted.

3. Analysis of Rebuttal Comments Concerning Mutagenicity

a. Basis of Presumption

i. Introduction

The Agency issued an RPAR against all inorganic arsenical pesticides on the basis of mutagenicity. The data presented in the PD-1 and summarized on Table II.C-1 of this document demonstrates that both trivalent (arsenite) and pentavalent (arsenate) forms of inorganic arsenic can act as mutagenic agents. These studies form the basis of the Rebuttable Presumption Against Registration (RPAR) for the inorganic arsenical pesticides based on the mutagenic effects criterion.

TABLE II.C-1

Summary of Studies of Inorganic Arsenic Mutagenicity

Study	Author(s)	Chemical(s)	Cell Type	Effects
Point Mutations	Picsor and Lo Piccolo, 1972	sodium arsenate	*E. Coli*	No reversions induced
	Moore, 1976	arsenic trioxide	*S. typhimurium*	Negative Ames' test (without metabolic activation).
	Nishioka, 1975	sodium arsenite	*E. coli*	Positive mutagen ; increased the frequency of mutation in 8-azaguanine treated cells.
	Casto, (Letter 1977a)	sodium arsenite	hamster lung cells	Positive mutagen; increased the frequency of mutation in 8-azaguanine treated cells.

TABLE II.C-1 Continued

Summary of studies of Inorganic Arsenic Mutagenicity

Study	Author(s)	Chemical(s)	Cell Type	Effects
Chromosal Effects In vitro Cytogenetics	Oppenheim and Fishbein, 1965	potassium arsenite	human peripheral leukocytes	Chromosome gaps, breaks, translocations, dicentrics, ring forms were found. Cell division was suppressed and there was an increased number of broken metaphase plates.
	Paton and Allison, 1972	sodium arsenite	human diploid fibroblasts	Chromatid breakage
		sodium arsenate	human diploid fibroblasts and leukocytes	Chromatid breakage Effect higher with sodium arsenite
In vivo Cytogenetics	Petres et al., 1970, 1977	unspecified	human lymphocytes (from psoriasis patients and wine-growers)	Aneuploidy, chromatid breaks, acentric fragments, and dicentric chromosomes occurred more frequently in cells from persons exposed to arsenic than in the controls.

TABLE II.C-1 Continued

Summary of Studies of Inorganic Arsenic Mutagenicity

Study	Author(s)	Chemical(s)	Cell Type	Effects
Dominant Lethal	Sram and Bencko 1974	sodium arsenite	ICR-SP mice	An acute oral dose (250 mg/kg) given to the male produced negative results. Chronic application over 4 generations of males at 10 mg/liter of drinking water gave positive results (increase in overall dominant and preimplantation lethality). A subtoxic dose (100 mg/liter) gave no change in frequency of dominant lethality or male fertility.
DNA Damage	Burgdorf *et al*., 1975	potassium	human	There was a higher rate of sister chromatid exchange in lymphocytes from patients who had used Fowler's solution compared to lymphocytes from unexposed controls.
DNA Repair (microbial)	Rossman *et al*., 1975, 1977	sodium arsenite	*E. Coli* (unexposed)	There was a decreased mutation frequency of irradiated cells that were excision-repair deficient. There was decreased survival rate of uv-exposed cells (wild type, excision-repair deficient). No effect was found on strains deficient in post-replication repair.

TABLE II.C-1 Cont

Summary of Studies of Inorganic Arsenic Mutagenicity

Study	Author(s)	Chemical(s)	Cell Type	Effects
	Nishioka, 1975	sodium arsenate sodium arsenate	Bacilus subtilis	Both chemicals were positive mutagens. The effect was stronger with sodium arsenite.
(mammalian)	Jung *et al*., 1969	sodium arsenate	human epidermal cells (exposed to xenon lamp)	DNA dark repair activity decreased in presence of sodium arsenate.
	Jung and Trachsel, 1970	sodium arsenate	human epidermal cells (exposed to xenon lamp)	DNA synthesis (reduce mitotic index) DNA dark repair were both inhibited in presence of sodium arsenate.
Metabolic and Cellular Toxicity Effects (*in vivo*)	Skipper *et al*., 1951	potassium arsenite	mice	There was reduced incorporation of ^{14}C-formate (precursor of mouse DNA-purines) into nucleic acid purines.

TABLE II.C-1 Continued

Summary of Studies of Inorganic Arsenic Mutagenicity

Study	Author(s)	Chemical(s)	Cell Type	Effects
	Petres and Berger, 1972	sodium arsenate	same	At high concentrations, the mitotic index decreased. There were metaphase plate pulverizations at low doses. There was inhibition of ^{3}H-thymidine incorporation into DNA.
	Petres et al., 1974	sodium arsenate	same	There was inhibition of ^{3}H-thymidine and ^{14}C-thymidine incorporation into DNA at lower doses than inhibition of ^{3}H-uridine and ^{14}C-uridine into RNA.
	Petres et al., 1975	sodium arsenate	same	After one hour of exposure, there was increasing inhibition of ^{14}C-thymidine incorporation into DNA.
	Baron et al., 1975	sodium arsenate	same	There was inhibition of ^{14}C-TTP into DNA and ^{14}C-UTP RNA. There was also inhibition of incorporation of labeled alanine and leucine into cellular proteins.

ii. Description of Studies

As described in detail on Table II.C-1, the inorganic arsenical compounds have been evaluated in several different mutagenicity test systems. Sodium arsenite and sodium arsenate have been shown to be mutagenic in both *in vitro* and *in vivo* tests. Gene (point) mutations occur in tests of sodium arsenite with bacterial systems #(*Escherichia coli*) (Nishioka, 1975) and mammalian (hamster) cells *in vitro* (Casto, 1977a). Chromosomal aberrations are caused by sodium arsenite and sodium arsenate, as seen in *in vitro* tests with human cells (Oppenheim and Fishbein, 1965; Paton and Allison, 1972), and in *in vivo* tests with mice (Sram and Bencko, 1974), and humans with known arsenic exposure (Petres *et al*., 1970, 1977). Potassium arsenite caused DNA damage in human lymphocytes *in vitro* (Burgdorf *et al*., 1977). DNA repair *in vitro* was decreased by sodium arsenite and sodium arsenate in ultraviolet light-exposed bacteria (*E. coli*) (Rossman *et al*., 1975, 1977), (*Bacillus subtilis*), (Nishioka, 1975), and by sodium arsenate in xenon lamp-exposed human epidermal cells (Jung *et al*., 1969; Jung and Trachsel, 1970). In addition, these inorganic arsenical compounds affected DNA synthesis and mitosis by their metabolic and cellular toxicity effects as demonstrated by *in vitro* and *in vivo* tests in mammalian systems (see Table II.C-1).

b. Analysis of Specific Comments

All rebutters' comments were reviewed. Many comments were of a testimonial nature or expressed opinions without supporting data. Several rebutters discussed the nutritional value of arsenic. The American Wood Preservers Institute's (AWPI) exhibit was the most comprehensive and contained additional studies not reviewed in PD-1. These studies (while not shown on the tables) are discussed in the following rebuttal comments.

Rebuttal Comment 1: No Direct, Multi-Test Evidence For Mutagenicity of Pentavalent Arsenic (2)

The AWPI rebuttal contains an independent analysis by Clement Associates of the references listed in Table 23 (Summary of Studies of Inorganic Arsenic Mutagenicity) PD-1. Clement Associates presented their opinions in a document entitled "Review of Evidence for Mutagenicity of Inorganic Arsenical Compounds," dated December 20, 1978. They presented their findings with respect to each study, and made an overall assessment of the extent to which the studies support the Agency's findings. Clement Associates state that the data presented in several of the studies provide evidence for the potential mutagenicity of inorganic arsenical compounds in bacterial and mammalian cell test systems. However, Clement Associates also state that these studies need to be repeated with a more quantitative protocol and that more data would be desirable. The conclusion that the studies need to be repeated provided the AWPI's basis for their rebuttal comment.

The AWPI rebuttal states: "In summary, therefore there are no studies that provide direct evidence of the mutagenicity of pentavalent arsenic compounds. The studies cited in the PD-1 certainly do not constitute 'multi-test' evidence of mutagenicity of pentavalent arsenic compounds." The AWPI rebuttal is in agreement with the independent analysis presented by Clement Associates and AWPI "believes that there is no support whatever, much less any multi-test support, for the Agency's rebuttable presumption that pentavalent arsenic induces mutagenic effects." The AWPI report goes on to state, "Even if one presumes the Agency's conclusions regarding _in vivo_ conversion (of pentavalent to trivalent arsenic) are correct, a proposition that clearly is not supportable for the reasons discussed in pages 14-45 of these rebuttal comments, there is still not sufficient evidence to establish that even trivalent arsenic induces mutagenic effects."

Agency Response: The criteria for mutagenicity has been amply met, as shown by the studies cited in Section II.C.3.a of this document. The positive dominant lethal test in mice _in vivo_, (Sram and Bencko 1974), and the chromosomal aberrations and aneuploidy which were associated with human exposure to arsenic _in vivo_ (Petres _et al_., 1970, 1977), support results of the the other tests and raise the suspicion that arsenic may pose a mutagenic hazard to humans. The Agency agrees with the rebutter that more quantitative data are desirable.

Rebuttal Comment 2: Pentavalent Arsenic Is Not a Mutagen (2)

The AWPI rebuttal contains an *in vivo* cytogenetic study in mice (Graham, 1979). This study shows that mice fed CCA-treated wood fibers (pentavalent arsenic) in the diet did not show a mutagenic response. Groups of three male mice were fed regular ration, regular ration with 10% wood fiber, or regular ration with 10% CCA-treated wood fiber. Mice were offered these diets for 2, 3, 7, 14, or 21 days. Three hours before sacrifice each mouse was injected intra-peritioneally with colchicine. Bone marrow was obtained and prepared for examination (fifty metaphase plates per mouse). The level of chromosome damage was the same for both the treated and control animals. A slight increase in polyploidy with increased exposure time in the CCA-fed mice was observed. The AWPI states that "the central fact of this test is clear: no mutagenic responses were noted."

Agency Response: The Agency has determined that the results of the experiment are inconclusive; the author states that the mice ate around their ration treated wih CCA and either lost weight or failed to gain weight. The fact that treated mice apparently did not consume part of the diet points out possible inadequacies in the study.

An accurate measure of food consumption could rule out a low amount of feeding as a possible cause of weight loss at days 14 and 21 in the CCA-treated mice. On the other hand, the increased incidence of polyploidy in the CCA-treated mice may indicate that some arsenic was ingested.

Rebuttal Comment 3: Effect of pH on Test Reliability (2)

AWPI states a number of general comments in rebuttal of the issuance of an RPAR against arsenic, based on multi-test evidence of mutagenicity. One comment referred to the effect of pH on test reliability. AWPI contends that the Agency must consider the pH effect of chemicals on the reliability of short-term mutagenesis assays before relying on them to determine whether to issue an RPAR.

Agency Response: No actual data were offered in support of this point. However, the Agency agrees that changes in pH may have a deleterious effect on cells. However, the rebutter did not present any information that directly supports a contention that the results of the mutagenicity tests in the PD-1 were compromised by changes in pH.

Rebuttal Comment 4: Three-Generation Reproduction Studies (2)

AWP1 claims that the preferred way to assess mutagenic risk is by three-generation reproduction studies.

Agency Response: The rebutter's argument did not show three-generation reproductive studies to be preferable to the types of mutagenicity studies listed in the PD-1 for assessing mutagenic risk. Further no data or statistical sensitivity discussions were offered to support this contention The results of the mutagenicity tests listed in PD-1 led to the Agency's presumption that arsenic causes several mutagenic effects, i.e., gene (point) mutations, chromosome aberations, changes in chromosome number, DNA damage, decreased DNA repair, and probably heritable genetic defects in mammals. The results of a three-generation reproduction test would not allow definitive conclusions to be drawn regarding the several possible mutagenic effects of the test compound as such a test is not designed to detect mutagenic events *per se* and will not detect all mutagenic end points of concern. Further, if mutagenic effects could be detected, the sensitivity of the 3-generation reproductive test is inadequate to assess the several mutagenic effects listed above.

Rebuttal Comment 5: No Mutagenic Response in 3-Generation
Studies of Morris et al. (1938) and
Kojima (1974) (2)

The AWPI notes that the two multi-generation studies of Morris et al. (1938) and Kojima (1974) could be interpreted to show that no mutagenic responses were noted in either study or at any generation.

Agency Response: The Morris et al. (1938) and Kojima (1974) studies were designed as reproduction studies, not mutagenicity studies. The Agency has determined that these studies do not evaluate mutagenicity and are therefore not relavent to the mutagenicity presumption (see discussion of previous Agency Response).

Rebuttal Comment 6: Toxic Threshold (2)

The rebutter (AWPI) contends that a "threshold dose" (not defined) exists before a toxic reaction is noted.

Agency Response: Unless proven otherwise, mutagenic effects are presumed to have no threshold. The Agency presumes that single molecules at the "target" site(s) may induce mutagenic events. This is different than the case for some other toxic effects, e.g. teratogenicity, where thresholds are currently believed to exist.

Rebuttal Comment 7: Toxicity Related to Acute Toxicity Rather Than to Mutagenesis (2)

The AWPI states that the toxic effects noted in Petres *et al.* (1974) (see Table II.C-1) are related to acute toxicity rather than mutagenesis.

Agency Response: No data was submitted by the rebutter in support of this comment. Mutagenicity tests represent a very sensitive means of detecting what are, after all, mutagenic events. Chromosomal damage, aneuploidy, increased point mutations, and other related effects summarized on Table II.C-1 of this document are all mutagenic events observed in various tests with inorganic arsenicals.

Rebuttal Comment 8: Lack of Human Effects (2)

The AWPI states that arsenic is not mutagenic in man.

Agency Response: The Petres *et al.* studies (1970, 1977), contained evidence that chromosomal damage had occurred in persons exposed to inorganic arsenical pesticides or to arsenical medications. Based on these findings and the many positive mutagenicity studies in Table II.C-1 of this document,the Agency believes that arsenic may induce mutagenic effects in the cells of humans.

Rebuttal Comment 9: Arsenic Mutagenic in Any Form (2)

AWPI states that the Agency has concluded that arsenic is mutagenic in any form.

Agency Response: The Agency does not agree that arsenic in any form is mutagenic. PD-1, page 166, only states "... without exception a rebuttable presumption against registration exists for all inorganic arsenical pesticides ...." Inorganic arsenical pesticides includes both pentavalent and trivalent arsenic but not all forms of arsenic, such as organic arsenical compounds. Organic arsenicals are considered nontoxic due to their metabolic pathway which differs considerably from the inorganic arsenical compounds.

Rebuttal Comment 10: Chromosome Damage and Cellular Toxicity (2)

The rebutter (AWPI) states that chromosome damage can be produced by a number of agents and that cellular toxicity must be clearly established before evaluating mutagenic responses. The rebutter does not further characterize these agents.

Agency Response: The Agency agrees that cytotoxic (cellular toxicity) effects can interfere with the assessment of the results of mutagenicity tests. However, the rebutter has not submitted data that shows that the mutagenicity study results cited in PD-1 were confounded by cytotoxicity.

Rebuttal Comment 11: Mammalian Mutagenicity Test System (213)

Texas A&M University claims no mammalian studies have suggested arsenic as a mutagen. Thus they feel some doubt as to whether any forms of arsenic are mutagenic.

Agency Response: The Agency notes at least two mammalian tests are significant with regard to the mutagenicity of arsenic: 1) the dominant lethal test of Sram and Bencko (1974) indicating heritable mutagenic effects in mice, and (2) the studies of Petres *et al*. (1970, 1977), showing that exposure to arsenic can cause chromosomal aberrations and aneuploidy in humans.

c. Summary of Rebuttal Comments Concerning Mutagenicity Conclusion

The inorganic arsenical compounds have been evaluated in several different tests for mutagenicity. The individual studies upon which the presumption is based are listed in Table II.C-1 of this document. Of particular concern are: 1) the positive result in the dominant lethal test of Sram and Bencko (1974), which indicated that inorganic arsenic reached the germ cells (gonads) and produced heritable mutagenic effects in mammals and 2) the studies by Petres *et al*. (1970, 1977) that showed that human exposure to arsenic can cause chromosomal aberrations and aneuploidy in humans in vivo.

The Agency concludes that, based on the evidence of mutagenicity cited in Table II.C-1, the risk criteria as set forth in 40 CFR 162.11 (a)(3()(ii)(A) have been exceeded for the inorganic arsenicals and that the mutagenicity presumption has not been rebutted.

4. Analysis of Rebuttal Comments Concerning Fetotoxic and Teratogenic Effects

a. Basis of Presumption

i. Introduction

The Agency concluded in PD-1 that a rebuttable presumption against the registration of all pentavalent and trivalent inorganic arsenical compounds exists. The presumption was based on these compounds' teratogenic and fetotoxic potential.

By way of introduction to the following discussion of teratogenicity and fetotoxicity as possible adverse effects of exposure to inorganic arsenicals, it will be useful to address some basic issues of definition. Generally, the term "teratogenic" is defined as the tendency to produce physical and/or functional defects in offspring *in utero*. The term "fetotoxic" has traditionally been used to describe a wide variety of embryonic and/or fetal divergences from the normal which cannot be classified as gross terata (birth defects) -- or which are of unknown or doubtful significance. Types of effects which fall under the very broad category of fetotoxic effects are death, reductions in fetal weight, enlarged renal pelvis, edema, and increased incidence of supernumary ribs. It should be emphasized, however, that the phenomena of terata and fetal toxicity as currently defined are not separable into precise categories. Rather, the spectrum of adverse embryonic/fetal effects is continuous, and all deviations from the normal must be considered as examples of developmental toxicity. Gross morphological terata represent but one aspect of this spectrum, and while the significance of such structural changes is more readily evaluated, such effects are not necessarily more serious than certain effects which are ordinarily classified as fetotoxic--fetal death being the most obvious example. The studies, which are summarized on Table 11.C-2 and described in the following paragraphs, form the basis of the teratology and fetotoxicity presumption against the inorganic arsenical compounds.

ii. Studies

There are several studies which show that arsenic administered by injection causes teratogenic and fetotoxic effects in animals. Although these studies will not be considered in the risk assessment due to their inappropriate (for humans) route of administration, they do demonstrate the teratogenic and fetotoxic effects of arsenic.

TABLE II.C-2

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment:	Gestation Day(s) Treated / Day(s) Sacrified	Dosage (mg/kg)	Effects
Beaudon, 1974	Sodium arsenate	Wistar rat	ip	$\frac{7 - 12}{20}$	20 - 50 single dose	Fetal resorption and malformation were dose-dependent and peaked on treatment days 9 and 10. 50 mg/kg was lethal to all embryos. There were no teratogenic effects on days 7 and 11 and few on day 12. Malformations: eye defects, exencephaly, renal agenesis, rib and vertebral defects.
Burk and Beaudoin, 1977	Sodium arsenate	Wistar rat	ip	$\frac{9 - 11}{20}$	30 - 50 single dose	Fetal resorption and malformation were greatest on day 9. Renal agenesis occurred mainly from treatment on day 10. Fetal weights declined significantly with treatment. Malformations: exencephaly, eye defects, facial clefts, agnathia, hydrocephalus, encephalomeningocele, diaphragmatic hernia.
			ip	$\frac{10}{11 - 16}$	45 single dose	Renal agenesis resulted mainly from growth retardation of the mesonerphric duct.

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TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment:	Gestation Day(s) Treated / Day(s) Sacrified	Dosage (mg/kg)	Effects
Ferm and Carpenter, 1968	Sodium arsenate	golden hamster	iv	8 / 12 - 14	5,20,40 single dose	No malformations at 5 mg/kg. All fetuses killed in uteron at 40 mg/kg. At 20 mg/kg, there were exencehalic lesions, bulging eyes, and protruding tongue and mandibles.
Holmberg and Ferm, 1969	Sodium arsenate	golden hamster	iv	8 / 13	20 single dose	There was fetal resorption and malformation: exencephaly, cleft palate and lop, anophthalmia, ear malformations.
Ferm et al., 1971	Sodium arsenate	golden hamster	iv	8 15	15,17.5, 20, 25 single dose	Embryo resorption and malformation were dpse-dependent. Malformations: exencephaly, rib defects, genitourinary defects, anencephaly, cleft lip and palate, anophthalmia, adrenal agenesis, prognathia. Genital abnormalities were greatest in females, and cleft lip, palate, and rib abnormalities were seen primarily in males.

TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment: Gestation Day(s) Treated	Day(s) Treated / Day(s) Sacrified	Dosage (mg/kg)	Effects
Hood, 1972	Sodium arsenate	albino Swiss-Webster mouse (CD-1 strain)	ip (in utero)	$\frac{7 - 12}{18}$	10,12 single dose	There was a high degree of resorption and reduced fetal weights that were day and dose-dependent. Malformations were highest on days 8 to 10. exencephaly, micrognathia, open eye, defective tail, skeletal defects.
Hood and Bishop, 1972	Sodium arsenate	albino Swiss-Webster mouse (CD-1 strain)	ip	$\frac{6 - 12}{18}$	25,45 single	At 25 mg/kg, there was no significant difference from the controls. At 45 mg/kg, there was increased resorption, especially from days 7 and 9. Fetal malformations were highest on days 7 to 11: exencephaly, shortened jaw, protruding tongue, anophthalmia exophthalmos, open eye, umbilical hernia, tail defects, hydrocephalus, and skeletal defects.
Hood and Pike, 1977	Sodium arsenate	albino Swiss-Webster mouse (CD-1 strain)	ip	$\frac{9}{18}$	40 single dose	There was a significant increase in fetal mortality, resorptions, and malformations. There was a decrease in fetal weights due to treatment.

TABLE II.C-2   Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment:	Gestation Day(s) Treated Day(s) Sacrified	Dosage (mg/kg)	Effects
Hood et al., 1977	Sodium arsenate	albino Swiss-Webster mouse (CD-1 strain)	ip	9 - 10 18	40	There was a significant increase in fetal mortality, resorptions, and malformations. There was a decrease in fetal weights due to treatment.
			oral (p.o.)		120 single dose	
Hood et al., (undated)	Sodium arsenate	albino Swiss-Webster mouse (CD-1 strain)	ip	7 - 15 18	40 single dose	There was a signigicant decrease of fetal weights from treatment on days 7 or 10. There was a significant increase in fetal resportion and death. (Prenatal mortality was higher than in the orally treated mice.) Treatment on days 9 or 10 resulted in increased malformations such as exencephaly, shortened jaw, open eyes, kinked tail, and skeletal defects.

TABLE II.C-2   Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment: Gestation		Dosage (mg/kg)	Effects
				Day(s) Treated Day(s) Sacrified		
Hood et al. (undated)	Sodium arsenate	Albino Swiss-Webster mouse (CD-1 strain)	oral (p.o.)	$\frac{7 - 15}{18}$	120 single dose	There was a significant reduction of fetal weights from treatment on days 10, 11, or 15. The number of dead or resorbed fetuses increased significantly the incidence of gross malformation, but a trend was evident. Malformations: Oligodactyly, micromelia, kinked tail. Skeletal defects increased significantly only from treatment on day 9 (same as with ip treatment).
Matsumoto et al., 1974	Sodium arsenite	mouse (ICR strain)	oral (p.o.)	$\frac{9 - 11}{18}$	10,20 40 daily dose	There were 5.7% (10 mg/kg), 0% (20 mg/kg), and 4.2% (40 mg/kg) fetal malformations compared to 0% for controls (no statistical values given). Malformations were bent tail, cleft palate, open eyelid, and bone deformities (40 mg/kg). There was reduced fetal growth and ossification of cervical vertrebrae and leg/tail bones.

TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment: Gestation Day(s) Treated Day(s) Sacrified		Dosage (mg/kg)	Effects
Matsumoto et al., 1974	Sodium arsenite	mouse (1CR strain)	ip	$\frac{6-11}{18}$	5,10 20 daily dose	There were 3.5% (5 mg/kg) and 1.3% (10 mg/kg) fetal malformations compared to 1.2% for controls (no statistical values given). Malformations were open eyelid, bent tail, club foot, and kidney deformity (10 mg/kg). As in oral treatment there was reduced growth and ossification.
Frank et al., 1936	Sodium arsenite	chicken embryo	injection	not speci-fied	0.01 - 1.0 ppm single dose(1)	There were only ectopic abnormalities (unsepcified) and these occurred at the lowest dosage. There were no abnormalities at 1.0 ppm.
Ridgway and Karnofsky, 1952	Potassium arsenite, Arsenic pentoxide, sodium arsenate	Leghorn chicken embryos	injection	$\frac{4-8}{18}$	0.2 mg/egg single dose(2)	Embryos injected on the fourth day with sodium arsenate were stunted with mild micromelia and abdominal edema. There were no effects in the eight-day old embryos.

TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment: Gestation Day(s) Treated Day(s) Sacrified		Dosage (mg/kg)	Effects
Puzanova and Doskocil, 1976	Pentavalent arsenic	Leghorn chicken embryos	injection	2 - 4 varied	3ug/egg single dose(3)	Embryos treated day 2 of incubation were normally differentiated. Of embryos (19) surviving day 3 treatment, 21% had abnormalities (deformed beak, lumbar lordosis, body distortion, wrinked brain vesicles, incomplete body walls). Thirteen (13) embryos survived day 4 treatment; 32.5% had abnormalities such as impaired mesonephros, kyphosis of body, hyperlordosis and small amnion. Compression of embryos in deformed amnion. Compression of embryos in deformed amnion may have caused defects.
Schroeder and Mitchner, 1971	Soluble arsenite salt	Charles River mouse	oral (drinking water)	through 3 generations	5ppm ad libitum(4)	Arsenic increased the ratio of males to females and reduced the litter size.

TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

Authors	Chemical(s)	Test Animal	Treatment: Gestation Day(s) Treated Day(s) Sacrified		Dosage (mg/kg)	Effects
Kimmel and Fowler, (letter 1977b)	Sodium arsenate Sodium arsenate	rat	oral (drinking water)	$\frac{1 - 21}{21}$	30,90 ppm ad libitum(5)	No adverse effects.
James et al., 1966	Potassium arsenate	Yearling ewe	oral (capsule)	treated for 18, 45,140 and 147 days	0.5 - 0.75	All lambs were normal. One lamb born to a ewe given 0.75 mg/kg (later reduced to 0.5 mg/kg due to toxicity) was very small.
Morris et al., 1938	Arsenic trioxide	Osborne - Mendel rat	oral (food)	treated from 4 wk. old to 1 yr.	27, 215 mg in diet(6)	There were no significant differences in fertility and fecundity between the experimental and control groups. This was also true of the F$_1$ generation when treated similarly.

TABLE II.C-2 Continued

Summary of Studies on Inorganic Arsenic Teratogenicity in Animals

			Treatment: Gestation			
Authors	Chemical(s)	Test Animal	Day(s) Treated Day(s) Sacrified		Dosage (mg/kg)	Effects
Kojima, 1974	Arsenic trioxide	Wistar rat	oral (food)	treated prior to and during gestation	10,50 100 ppm in diet(7)	No significant differences in the number of litters between treated and control rats.

1. Total As: 0.01 - 1.0 mg/kg (Franke et al., 1936).
2. Total As: 4 mg/kg (Romanoff and Romanoff, 1949).
3. Total As: 0.06 mg/kg (Romanoff and Romanoff, 1949).
4. Daily dose for adult females 0.56 - 2.0 mg/kg (Letter 1978).
5. Total As: 2.25-3.75 mg/kg; 6.75-11.25 mg/kg (Letter 1977b).
6. 9.2 mg/kg/day; 79 mg/kg/day (Morris et al., 1938).
7. Total As: 15.4 mg/kg; 77.1 mg/kg; 154.3 mg/kg (Kojima, 1974).

Beaudoin (1974) injected pregnant Wistar rats with varying doses of sodium arsenate and observed dose dependent fetal resorption and malformations. Fetal resorption and malformations such as exencepholy, eye detects, facial clefts, agnathia, etc., in Wistar rats injected with varying doses of sodium arsenate were also described by Burk and Beaudoin (1977). Holmberg and Ferm (1969) reported 49% malformed embryos and 35% resorbed embryoes in golden hamsters injected with varying doses of sodium arsenate. Ferm et al. (1971) observed dose-dependent teratogenic effects (embryo resorption, malformations) in golden hamsters injected with sodium arsenate. Further a high degree of resorption and reduced fetal weights that were day and dose dependent were observed by Hood (1972) in albino Swiss Webster mice injected with sodium arsenate. Malformations were highest when doses occured on days 8 to 10. Hood and Bishop (1972) described dose-dependent fetal malformations in Swiss Webster mice injected with sodium arsenate and Hood and Pike (1977) observed an increase fetal mortality, resorptions, and malformations in Swiss Webster mice with a single dose of sodium arsenate.

Franke et al. (1936) reported ectopic abnormalities in chicken embryos injected with a single 0.01 ppm dose of sodium arsenate (0.01 ppm corresponds to 1.0 mg/kg total arsenic). Ridgeway and Karnofsky (1952) reported leghorn chicken embryos injected on the fourth day with sodium arsenate were stunted and had mild micromelia and abdominal edema. Puzanova and Doskocil (1976) described teratogenic effects of pentavalent arsenic on Leghorn chicken embryos.

In the following studies arsenic administered orally caused teratogenic and fetotoxic effects.

Hood _et_ _al_. (1977, 1978) showed effects on fetal mortality, weight, and malformations in mice treated with sodium orally and by intraperitoneal injection. Arsenate was more potent when administered by injection than by oral means.

Matsumoto _et_ _al_. (1974) reported no significant increase in fetal malformations, when pregnant mice were gavaged with 0, 10, 20 or 40 mg/kg/day sodium arsenite on days 9, 10, and 11 of gestation. Fetotoxicity was evident at all levels tested and was expressed as reduced fetal body weights and reduced placenta weights. At 40 mg/kg/day there was a significant increase in the incident of dead or resorbed fetuses (30.4% compared to 9.8% for controls; $P \leq 0.001$). In addition Schroeder and Mitchner (1971) observed an increased ratio of males to females and reduced litter size in Charles River mice orally ingesting an arsenite salt solution.

Although maternal toxicity was mentioned in one of the studies, (Hood, 1978) no data was provided by the author. Thus the degree of maternal toxicity could not be evaluated.

The following four studies showed no teratogenic or fetotoxic effects in laboratory animals exposed to various inorganic arsenicals at the dose levels reported.

Kimmel and Fowler (1977b, letter) reported no teratogenic or fetotoxic effects in pregnant rats given 30 or 90 ppm sodium arsenite and arsenate in the drinking water from day 1 through day 21 of gestation. (These levels are equivalent to 4.8 and 14.4 mg/kg/day respectively.) The parameters the authors measured were fetal weights, number of fetuses per litter, number of malformations, maternal weights, and food and water consumption. The arsenic compounds had no effect on these parameters. The fetuses were examined prenatally in this study, thus ruling out the possibility of maternal cannibalism of defective pups, or loss of pups through post-natal mortality due to undetected visceral or skeletal abnormalities.

James _et al_. (1966) fed four pregnant yearling ewes potassium arsenate via gelatin capsule; three ewes produced normal lambs, the fourth ewe produced a very small lamb. Morris _et al_. (1938) fed rats varying doses of arsenic trioxide; there were no significant differences in the number of litters between treated and control rats.

Kojima (1974) orally administered arsenic trioxide at 10, 50 and 100 ppm (corresponds to 0.5, 2.5, and 5 mg/kg/day) in the food to Wister rats prior to and during gestation. This treatment caused no significant effect on the number of litters. It must be noted that this study is a reproduction, not a teratogenicity study, since effects in the unborn fetuses were not assessed.

iii. Additional Reviews Epidemiological Studies

Studies of pregnant women employed at the Ronnskar Smelter in Sweden provided information with direct bearing on the issue of human teratogenicity of inorganic arsenicals. The studies were concerned with variations in birth weights of offspring (Nordstrom et al., 1978a; 1979a; Beckman et al., 1979), spontaneous abortions (Nordstrom et al., 1978b; 1979a; Beckman et al., 1979) and congenital malformations (Nordstrom et al., 1979b; Beckman et al., 1979). The Ronnskar smelter produces copper (57,000 tons), lead (38,7000 tons), refined arsenic (10,500 tons), crude arsenic (900 tons), other metals, sulfuric acid (139,000 tons) and liquid sulfur dioxide (29,8000 tons) (1975 figures, Nordstrom et al., 1978a). The studies discussed here were mainly concerned with copper and arsenic exposure.

A pilot study examined the relationship between airborne arsenic exposure and urinary arsenic excretion among employees at the Ronnskar smelter (Carlsson, 1976). A group of employees from various departments within the facility were tested for urinary arsenic concentrations following respiratory exposure to ambient air during a work day. Workers wore special collecting masks during the work day in order to measure arsenic exposure. A weighted 8-hour average exposure for each worker was then calculated. Inhalation exposure invariably was accompanied by presence of urinary arsenic.

Birth weights among offspring of pregnant employees was compared by employee location at the smelter (factory, laboratory or administrative employment) (Nordstrom et al., 1978). The totals were compared with birth weights in the near-by industrial population and with birth weights in populations at a distance from smelter. Birth weights of offspring of all employees and in two small industrial populations close by were statistically significantly decreased from normal values. A parity dependence was also shown, with birth weights decreased in parous two women and above (Nordstrom et al., 1978b; 1979a). Smoking was among parameters considered in birth weight measurement. It was acknowledged that smoking during pregnancy is associated with decreased birth weights as well as shortness of gestation and could possibly have an additive effect in the study discussed (Nordstrom et al., 1979a).

Frequencies of spontaneous abortion were highest in pregnancies where the mother was employed during pregnancy (13.9%) or had been employed before pregnancy and was living near the smelter (17.0%) (Nordstrom, et al., 1979a). The difference between the two groups was significant ($p < 0.005$), especially in subsequent pregancies ($P < 0.0005$). In women occupied in close connection with smelting, the abortion frequency was higher than in other employees ($P < 0.01$). When the father was employed at the smelter as well, the frequency of abortion was higher (19.4%)

than if the mother alone was employed (13.5%). The highest abortion frequencies were found in women who were employed during pregnancy and in women who were employed before pregnancy or were still living close to the smelter.

In a study of congenital malformation frequency in offspring of female employees at Ronnskar, three groups of offspring were examined (Nordstrom et al., 1979b). These were offspring of parents employed after, during, or before pregnancy. Total malformations, total live born and multiple malformations were tallied. Statistically significant increases in numbers of congenital malformations and multiple malformations were found in children of mothers who worked during pregnancy. The incidence of malformations was doubled and the percent of multiple malformations was quadrupled from that of normal values. (The value for cogenital malformation for smelter employees was 51.4%; for normals in a hospital region the value was 28.9%. For multiple malformations, the value for smelter employees was 19.8%. The value for normals in a hospital regions was 4.6%.)

Data on the teratogenicity of inorganic arsenicals in humans are limited to references from epidmiological studies of women employees exposed to a number of toxic substances in a smelter. Air sampling analysis of ambient air and urinanalysis of employees indicated workers were exposed to arsenic (although test for other sustances were not reported). Birth weights of offspring born to women employees were significantly decreased from those in a normal population. Decreased birth weight was also found among offspring of individuals who had been employed or were still living near the smelter. In addition, decreased birth weight correlated with the parity of pregnancy; normally, birth weights of subsequent offspring increase with parity. The frequency of spontaneous abortions in women employees was increased above normal. Values were highest for women employed during pregnancy or employed before pregnancy and living close to the smelter. The frequency of congenital malformtions among progeny of female employees was twice that of other women in the region. The frequency of multiple malformations in offspring of female employees was four-fold higher.

It is clear that pregnant female employees employed at a smelter demonstrated effects from exposure to toxic substances, however, inorganic arsenicals cannot be implicated as the sole cause. Thus, the Agency will use these epidemiologicval studies as supporting evidence of fetotoxic and teratogenic effects and not in the formal risk assessment.
The Agency has considered all comments submitted in response to this presumption and those comments are set forth below.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: Inappropriate Route of Exposure
(1, 2, 134)

Pennwalt Corp., the American Wood Preservers Institute (AWPI), and Bonide Chemical Co., express concern that, due to the route of exposure, the studies listed in Table 24 of PD-1 (Summary of Studies on Inorganic Arsenic Teratogenicity in Animals) and described in II.4.a of this document do not support a teratogenic or fetotoxic presumption against the inorganic arsenicals.

These rebutters state that intravenous (iv) and intraperitoneal (ip) injections of arsenate and arsenite in these studies cannot be utilized to assess teratogenic risks to humans since the human exposure to wood preservatives and untreated wood is either by dermal or inhalation routes.

In addition, the rebutter contends that the magnitude of exposure to the wood preservatives is much less than the high dose levels cited in the PD-1 studies.

Agency Response: Inorganic arsenic has been demonstrated to be both teratogenic and fetotoxic by the oral route (Hood *et al*., 1977). The results were statistically significant for both toxic effects.

The rebutters comment regarding the magnitude of exposure used in the PD-1 estimates versus the level of exposure to the wood preservatives will be discussed in the teratology and fetotoxicity risk assessment.

The Agency agrees with the rebutters however that extrapolating teratogenic effects produced in mice, rats, and hamsters by administering sublethal doses of arsenate or arsenites by the iv or ip route to risk factors in humans is of limited value in a quantitative risk assessment. In assessing the type of toxicity that a chemical possess, the iv and ip routes of exposure are of value as supporting evidence of teratology and fetotoxicity.

The Agency agrees to reject those studies using injected materials in quantifying the human risk.

Rebuttal Comment 2: Acute doses of arsenate in the maternal lethal range may present an embryolethal hazard but not a teratogenic one (2)

The AWPI states that Hood et al. (1977) compared the effect of ip vs. gastric intubation (oral). Several significant points should be noted in this work. First, the doses given were in the sublethal range resulting in oral-dosed mice with maternal death rates averaging 16%. This exceeds the Agency's criteria of no more than 10% maternal deaths under these circumstances. Second, even though the oral doses were sublethal, resorption and embryo death rates were less than half those found in the ip administered mice. Third, whereas the ip administered mice showed high rates of malformation (15-34% at 40 mg/kg and 26-63% at 56 mg/kg), the orally administered mice showed an insignificant malformation rate of 1-3%.

Agency Response: The Agency agrees that the Hood et al. (1977) study shows greater teratogenic effects with ip injected mice than with orally dosed mice. However, in the Hood et al. (1978) study arsenate administered orally to mice caused significant teratogenic effects. The Agency agrees that Hood et al. (1977) reported a significant maternal death* rate. However Matsumoto et al. (1974), who used arsenite rather than arsenate, reported significant fetotoxicity at 10 mg/kg with no maternal toxicity. The Agency therefore believes that the level of maternal toxicity that occurs at arsenic doses which also cause significant teratogenicity and fetotoxicity effects needs to befurther investigated.

Rebuttal Comment 3: Arsenic Does Not Produce Teratogenic Effects (2)

The AWPI states that Kojima (1974) investigated the effects on pregnancy, birth lactation and growth in which adults and/or litters were fed 10, 50, or 100 ppm of arsenic trioxide in a series of experiments. The author concludes that the arsenic did not produce significant differences from negative controls in the parameters studied.

Agency Response: The Kojima study was not a teratology or fetotoxicity study; it was a reproduction study. There was no pre-natal examination of fetuses. Moreover, the doses Kojima used were substantially lower than those which Hood et al.

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* A further discussion of maternal toxicity appears in the risk assessment.

(1977) used (120 mg/kg); these doses are equivalent to 0.5, 2.5 and 5.0 mg/kg/day, respectively.

Rebuttal Comment 4: No Significant Increases in Fetal Malformations (2)

The AWPI rebuttal states that Matsumoto *et al*. (1974) administered sodium arsenite to pregnant female mice by gavage for 3 days at selected times during gestation at dosages of 10, 20 and 40 mg/kg. And although the author apparently observed some fetal malformations (teratogenicity), such malformations were not statistically significant and were not dose-related.

Agency Response: The Agency agrees that no statistically significant increases in fetal malformations (teratogenicity) were reported in this study. However, fetotoxicity was evident at all levels tested, and was expressed as reduced fetal body weights and reduced placenta weights. At 10 mg/kg of sodium arsenite, there was a statisically significant increase in fetotoxicity. Therefore, since a no-effect level has not been demonstrated in this study, based on finding fetotoxic effects at all levels, it may not be used to estimate risk.

Rebuttal Comment 5: No Teratogenic Effects (2)

The AWPI states that five of eight oral dosing studies in the PD-1 found no adverse effects, including teratogenic effects, even when trivalent arsenic was used (Schroedoer *et al.*, 1971;

Kimmel and Fowler, 1977b; James _et_ _al_., 1966; Morris _et_ _al_., 1938; and Kojima, 1974).

Agency Response: The studies of Schroeder, Morris and Kojima were reproduction studies, not teratology studies. In a teratology study, the fetuses are removed from the dam and examined prior to with, which precludes the possibility of maternal cannibalism or early post-natal death which could be due to malformation. Thus, to infer lack of teratogenicity in a study from a lack of reproductive effects on fetuses is untenable. The Agency agrees, however, that no teratogenic events were reported in the Kimmel and Fowler, and James reports. The doses used were substantially lower than the oral doses used by Hood _et_ _al_. Being Kimmel and Fowler, 6.5 (arsenate) and 4.4 (arsenite) mg/kg/day*, and James, 50 mg/kg/day arsenate, respectively, as opposed to Hood _et_ _al_. (1978), who used 120 mg/kg/day.

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* The relationship between the doses used in these studies' and arsenic exposure levels in treatment plants will be addressed in the risk assessment.

Rebutter Comment 6: Pentavalent Arsenic is not a Teratogen (2)

The AWPI claims that the Matsumoto et al. (1974) study is not directly relevant to pentavalent arsenic wood preservatives because trivalent sodium arsenite was used.

Agency Response: In the PD-1 both wood and non wood uses of inorganic arsenic were presumed against. Therefore, both the trivalent and pentavalent forms of arsenic have been presumed against. The Agency agrees that Matsumoto study used trivalent arsenic however, there is ample supporting evidence (see Table 24 in PD-1 "Summary of Studies on Inorganic Arsenic Teratogenicity in Animals") and Section II.C.4.a of this document to implicate pentavalent arsenic as being fetotoxic and teratogenic.

Rebuttal Comment 7: No Teratogenic or Fetotoxic Effects from Dermal Exposure to CCA (2)

The AWPI states that the major route of exposure is dermal, and rabbit dermal teratology studies show that chromated copper arsenate (CCA) treated wood, when applied to the skin of pregnant rabbits does not produce teratogenic effects or other injury in the offspring.

The AWPI commissioned Dr. Ronald Hood to undertake two teratology studies involving dermal exposure to gravid rabbits and oral exposure to gravid mice. This report is submitted by AWPI as Appendix #4, Vol. III.

In the first study Hood, (unpublished, 1979), treated gravid rabbits with 26 grams of sawdust made from wood treated with 0.66 CCA lb./ft.^{3} and applied it dermally as an aqueous paste. The paste was applied on days seven through twenty of gestation and the arsenic content in the paste was 35%. There were a number of rabbits which failed to thrive in both treated and control groups, but this was attributed to handling and stressing the animals. Blood samples taken upon termination, at 29 days, contained less than 1 ppm arsenic in the CCA-treated do rabbits. The results were negative for teratogenic and fetotoxic effects.

The level of pentavalent arsenic in treated wood is 0.66 pounds per ft^3 which in this experiment is equivalent to 8.56 mg of As_2O_5 kg/cubic foot of treated wood. Assuming 100% dermal exposure, this is equivalent to a dose of 58.4 mg As_2O_5/kg body weight/day.

In the second study Hood fed gravid mice diets composed of 90% standard ration and 10% treated wood sawdust, 90% standard ration and 10% untreated wood sawdust or 100% standard ration. The results were negative in all groups for teratogenic or fetotoxic effects. The dietary exposure/dose in this study was 40 mg As_2O_5/kg body weight/day.

Three recent unpublished and confidential studies undertaken by Peoples, and Peoples and Parker were submitted by AWPI.

These included chromated copper arsenate (CCA) and/or ammoniacal copper arsenate (ACA) dermal absorption, ingestion, and excretion studies in dogs. The findings in both studies were essentially negative. There was no dermal absorption as measured by the amount of arsenic excreted in urine. Virtually all of the arsenic ingested was recovered in the urine and feces of dogs as methylated compounds, 90% of which were dimethylarsenic acid (DMA). No trivalent arsenic was excreted.

Agency Response: The Agency cannot use these studies for risk assessment purposes since the material being tested was CCA-treated wood particles, not inorganic arsenic *per se*; hence it is not possible to make a direct comparison with the other oral exposure studies evaluated in PD-1.

The Agency agrees with AWPI that no teratogenic or fetotoxic signs were demonstrated at the levels tested for dermal toxicity. However, there are two major routes of exposure in the treatment plant, inhalation and dermal, and a minor route, oral.

In the studies by Peoples, and Peoples and Parker the authors only address the dermal component of the risk.

The Agency concludes that the above considerations support the Rebutter's contention that dermal exposure to CCA-treated sawdust will not produce harmful effects in offspring. No conclusion however can be drawn concerning the effects of oral and inhalation exposure on teratogenic and fetotoxic events.

Rebuttal Comment 8: Arsenical wood preservatives are fixed in the wood (2)

The AWPI claims that the absence of arsenic in blood of rabbits (see comment 7 above) confirms that arsenical wood preservatives are fixed in wood in a highly insoluble state that allows little or no dermal absorption.

Agency Response: The study (Hood unpublished 1979) by itself does not support the rebutter's conclusion. The blood samples cited were taken on day 29, at termination of the experiment. However, exposure had ceased on day 20. This could provide ample time for any arsenic that might have been absorbed across the skin to be metabolized or excreted from the body.

Rebuttal Comment 9: Lack of Epidemiological Evidence (188)

Woolfolk Chemical Works, Inc., states that mutagenic and reproductive risks to humans are theoretical risks demonstrated only in laboratory animals. No study, to the rebutter's knowledge, has indicated any suspicious effects of the arsenical pesticides to humans from a mutagenic or reproductive standpoint in more than 50 years of use.

Agency Response: The presence of a valid epidemiological study is always helpful, but does not remove the Agency's concern that for any demonstrated teratogenicity and fetotoxicity in animals there exists an adequate margin of safety between the exposure level of a human population and the dosage level producing significant adverse effects in the young of treated animals.

Further, in this section, and in the teratogenicity and fetotoxicity and mutagenicity, risk assessments contained in Section II.C.8 of this document, epidemiological evidence is presented that indicates that arsenic causes teratogenic, fetotoxic, and mutagenic effects in humans. This evidence was not presented in the PD-1. Therefore it is summarized here, and further discussed in the risk assessment portion of this document.

Epidemiological studies of the Ronskar smelter in Sweden shows that the arsenic from the smelter caused decreased birth weights, spontaneous abortions, and congenital malformations (teratogenicity) in exposed humans (Nordstrom et al., 1978a; 1978b; 1979a; 1979b; Beckman et al., 1979; Carlson et al., 1976). Persons working and/or living near the smelter showed stastically significant increaces of fetotoxic and teratogenic effects and had significant elevated urinary arsenic levels, which were related to their inhalation exposure doses as measured by collecting masks. Although it is clear that pregnant female smelter employees experienced significant teratogenic and fetotoxic effects, arsenic cannot be indicated as the sole cause of the observed effects in these epidemiological studies.

Rebuttal Comment 10: Relative Toxicity (120, 134, 213)

Bonide Chemical Co., Prof. R.D. Hood, and Texas A & M University state that in most of the reproduction and fetotoxicity studies undertaken with inorganic arsenicals, the dosage levels utilized in mammalian systems have shown that arsenic at very high dosages, approaching the LD-50 for the individual species* has proven to be fetotoxic. For example, the study of Hood *et al.* (1977), showed that administration of as much as 120 mg sodium arsenate per kg was necessary before teratogenic effects were observed. The author notes that an equivalent dose (7.2 gms) for a 60 kg woman would be lethal long before teratogenic effects would be induced. Further, the rebutters emphasize that any toxic or infectious disease condition induced in a pregnant female, during certain susceptible periods of pregnancy, will cause either fetal toxicity, fetal death or malformations resulting from cytotoxic effects rather than teratogenic effects.

Agency Response: The Hood *et al.* (1977) study reported significant maternal deaths at the arsenate dose level that caused the reported significant fetotoxiic aand teratogenic effects, however, the Matsumoto *et al*. (1974) study reported significant fetotoxic effects for arsenite doses of 10 mg/kg with no reported maternal toxicity. The Agency therefore believes that the level of maternal toxicity that occurs at arsenic dosages which cause teratogenic and fetotoxiic effects need to be further defined.

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* Available LD_{50} data is summarized on Table II C-11 of this document.

In addition, there is a significant amount of evidence that indicates that humans are more sensitive to the toxic effects of arsenic than are rodents*.

Rebuttal Comment 11: Beneficial Effects (2, 133, 134)

AWPI, F.H. Nielsen Ph.D., and Bonide Chemical Co., state that arsenic is an essential element to the human body e.g., for nerve impulse transmission and the structure of keratin tissues. The rebutters submitted summaries of studies reporting the beneficial effects of arsenic in humans and animals.

Agency Response: The fact that a substance is reportedly beneficial in certain forms or quantities does not directly effect the hazard from any reported adverse effects which may pertain to other chemical forms or different concentration ranges. The Agency is concerned that a sufficient margin of safety exists (or that an acceptable risk pertain) with respect to the level of human exposure relative to the exposure level producing adverse effects of the material in either animals or man.

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* See the Agency Response to rebuttal comment 1, in Section II.C.5 of this document.

Rebuttal Comment 12: No Teratology Effects Observed from Oral Administration of Arsenic (1)

Pennwalt Corp., states that no teratogenesis was reported at any dose level by oral administration of inorganic arsenic. The comment states that the data of Hood et al. (1977), in which pregnant rats were administered sodium arsenate by gavage showed no increase in fetal malformations up to a dose of 100 mg/kg. In the opinion of the rebutter, even at the highest dose (120 mg/kg) the data showed no statistically significant differences compared to natural malformation rates.

Agency Response: The Agency disagrees with the rebutter as Hood et al. (1978) observed that 120 mg/kg of arsenate administered orally to mice significantly increased skeletal defects and prenatal mortality in the litters.

c. Summary of Rebuttal Comments Concening Fetotoxic and Teratogenic Effects: Conclusion

Twelve of the studies used by the Agency in the PD-1 presumption against inorganic arsenical wood preservatives will not be considered in the risk assessment because the intravenous and intraperitioneal routes of administration are considered by the

Agency as inappropriate for human exposure. These studies, however, are still considered to be supportive of the teratology and fetotoxic presumption. Three of the PD-1 studies will also not be considered in the risk assessment as the species used was avian, not mammalian and therefore not relavent to human hazard evaluation. The Hood et al. (1977) study showed unrebutted evidence of the teratogenicity of inorganic arsenic. Matsumoto et al.(1974) reported fetotoxic effects at an arsenic dose of 10 mg/kg in the mouse.

Further, epidemiological studies showed that human exposure at an arsenic smelter resulted in fetotoxic and teratogenic effects to the exposed persons.

In summary, the Agency concludes that the risk criteria for teratogenicity and fetotoxicity of inorganic arsenicals remains unrebutted. That is, there is evidence of teratogenic and fetotoxic effects which remain unrebutted. The issue of how these effects relate to exposure and hence the thresholds for these effects (the NOEL) will be addressed in the teratology and fetotoxicity risk assessment portion of this document.

5. Other Health and Environmental Concerns: Delayed Neurotoxicity

a. Basis of Concern

i. Introduction

In PD-1 three studies indicated possible delayed neurotoxic effects from exposure to the inorganic arsenical compounds. However, there was and still is insufficient evidence to initiate an RPAR on the basis of delayed neurotoxicity.

ii. Summary of Studies

The first study (Landau et al., 1977) attempted to relate arsenic exposure of workers in a copper smelter to neurological changes as compared to groups of aluminum smelter and non-industrial workers. In addition to arsenic, the copper smelter workers were, also exposed to increased levels of lead, copper, nickel, zinc as well as numerous other chemicals. The Agency believes that a similar correlation could have been found for lead, copper, cadmium, nickel, as well as for arsenic. The cause effect relationship in this study is therefore uncertain.

The second study, (Mizuta et al., 1956) reported on 220 patients poisoned by ingestion of roughly 3 mg of arsenic (probably calcium arsenate in arsenic-contaminated soy sauce) daily for 2 to 3 weeks. Twenty % of the patients were found to have peripheral neuropathy. The patients' other symptoms tended to diminish after 5 or 6 days despite continued intake of arsenic; however, neurologic symptoms became prominent as long as 2 weeks after arsenic ingestion was discontinued. Arsenic content of urine and hair also remained high.

The third study, Ohira and Aoyama (1973), was an epidemiological study on Japanese babies that drank arsenic-tainted milk. The authors found that the exposed group had statistically significant higher rates of many physical and medical problems when compared to the two control groups. The victims had lower intelligence quotients, a higher rate of severe retardation, a higher prevalence of myopia, abnormal EEG findings, a higher rate of decayed, missing, or filled teeth, and abnormal x-ray findings in facial shape. The authors concluded that the victims were still suffering from many physical and mental disorders after 17 years.

iii. Additional Reviews

These reviews come almost entirely from clinical reports resulting from homocidal or accidental injection of arsenic compounds, non-pesticidal contamination of food, or use of medication. In these reviews usually the amounts of arsenic injested or absorbed as well as controls are lacking. In addition, insufficient data presently exist to allow for characterization of quantitative dose/response relationships.

Arsenic effects on the peripheral nervous system have been reported by Reynolds (1901); Silver and Wainman (1952); Mizuta _et_ _al_. (1956); Heyman _et_ _al_. (1956); Jenkins, (1966); Hara _et_ _al_. (1968); Chhuttani _et_ _al_. (1967); Ishinishi _et_ _al_. (1973); Nakamura _et_ _al_. (1973); Nagamatsu and Igata (1975); O' Shaughness and Kraft (1976); Frank (1976); Garb and Hine (1977); LeQuesne and McLeod (1977); and are now recognized as classic clinical symptoms of arsenic poisoning. These symptoms usually become manifest within one to two weeks post ingestion. Recovery is slow, ordinarily starting between one and two months from the onset of symptoms, and the degree of recovery depends on the severity of the symptoms. Such symptoms include peripheral sensory effects characterized by the appearance of numbness, tingling, or "pins and needles" sensations in the hands and feet, as well as decreases in touch, pain, and temperature sensations in a symmetrical "stocking glove" distribution. These symptoms are often variously accompanied by burning sensations, sharp or shooting pains, and marked muscle tenderness in the extremities. Peripheral neuritis symptoms originate distally and, over the course of a few weeks, often progressively become more widespread in both lower and upper extremities, usually appearing first in the feet and later in the hands.

There are two case reports on cutaneous absorption of arsenic resulting in peripheral neuropathy of the sensimotor type, Robinson (1975); Garb and Hine (1977). In the latter case visual symptoms also appeared. This source of arsenic in the first case was topical application of a caustic paste in which the form of arsenic was not specified. The other case involved a worker, who was splashed with arsenic acid in an industrial accident.

There are few long-term animal feeding studies and those which are available have limited value for determining neurotoxicity. For example, beagle dogs in groups of 6 were fed diets containing sodium arsenate or sodium arsenite for two years (Byron _et al_., 1967). At concentrations of 50 ppm and less no difference from controls were detected. Unfortunately no histopathology of the nervous system was reported. In these studies results are generally unsatisfactory in regard to estimating dosage parameters associated with the arsenic induction of peripheral neuropathies from reports of human exposures. It is usually not possible to determine the precise dose involved or, in many cases, the period of exposure.

For subacute or chronic poisoning situations, information has been provided in only a few studies by which effective exposure parameters can be estimated (see Mizuta _et al_., 1956, Part 11.5.a)

Tay and Seath (1975) examined 74 patients who had taken anti-asthmatic herbal preparations containing up to 107 g/kg inorganic arsenic. The recommended daily dosage resulted in an intake of 3.3 mg for patients who took one kind of pill which contained arsenic trioxide, and 10.3 mg for patients who took another type, which contained arsenic sulfide. Arsenic levels in hair were over 1 mg/kg in 45% of the patients. Cutaneous manifestations of arsenic contamination were found in 92% of the patients. Over half of the patients presented neurological complications, the most common being sensimotor polyneuropathy. The significance of the findings cannot be evaluated, as no control group was reported.

Silver and Wainman (1952) described a patient that had ingested approximately 8.8 mg of arsenic trioxide daily for 28 months as an asthma treatment. Signs of peripheral neuropathy appeared at about 2 years, well after the onset of other arsenic-related effects, e.g., skin changes. Assuming regular ingestion of the arsenical each day for two years, the neuropathy effects would appear to be associated with the gradual exposure to a maximum total dose of up to 650 mg or so of arsenic.

Persistent neurotoxic central nervous system effects in babies have been reported as well as indications of nervous system damage in a laboratory animal fetus.

The Moringa milk poisoning incident occurred in 1955-1956. This resulted in an outbreak of arsenic toxicosis in Japan and was the result of infants having consumed powered milk contaminated with As_2O_3 at concentrations of 25-29 ppm. A total of 12,083 cases of poisoning were reported with 128 deaths. The arsenic was introduced into the dried milk as a contaminant of a sodium phosphate stabilizer.

Epidemiological follow-up studies, undertaken several years after the Morinaga milk poisoning incident, have been reported (Yamashita et al., 1972; Ohira and Aoyama, 1972). They purport to show statistically significant evidence for the persistence of residual inner ear hearing loss and also sight impairment. These findings were further supported by the following animal studies.

Westernhagen (1970) reported pathological and histochemical changes in the inner ear of guinea pigs exposed to arsenic trioxide at 1 mg/kg dose level for 28 days. Effects on the ear were also reported by Aly et al. (1975) in experimental animals treated with inorganic arsenic. Destruction of the organ of Corti and loss of Reissemer's membrane, causing deafness, were observed in guinea pigs given sodium arsenate intraperitioneally for two months (Aly et al., 1975). The dose reported was 0.2 mg sodium arsenate for each kg of body weight without closer specifiction. Further investigations by Aly et al. (1975) gave evidence of diminished acetyl cholinesterase activity in the temporal lobe and decreased blood cholinesterase levels in the exposed animals.

Cholinesterase inhibition was also observed in rats exposed for three months to arsenic trioxide in the form of condensation aerosols containing 46 ug/m^3 arsenic (Rosenshtein, 1970). Disturbances in the functional state of the central nervous system, measured as conditioned reflexes and chronaximetry, were evident. Histopathological changes in the brain included pericellular edema, plasmatic impregnation of the vascular walls, neuron plasmolysis and karyolysis. Several of the effects mentioned, although less marked, were also observed in a group of cats exposed to an aerosol containing 3.7 ug/m^3 arsenic. Osato (1977) gave suckling rats 2 and 10 mg of arsenic trioxide through a stomach tube for 40 days. The central nervous system was affected as indicated by a significantly poorer performance in the avoidance conditioning test in both groups of exposed animals. No particular histo-pathological brain changes of note could be found in these animals.

Ferm and Carpenter (1968) have reported a high incidence of exencephaly in golden hamster embryos of mothers given a 20 mg/kg intravenous dose of sodium arsenate on day 8 of gestation. Ferm et al. (1971) have subsequently demonstrated that these anomalies and high incidence of fetal resportions were dependent on the time of injection during critical stages of embryogenesis. Exenceohaly and many other malformations have been reported in offspring of mice given intraperitoneal injections of arsenate (25 mg/kg) during gestation (Hood and Bishop, 1972).

The above studies indicate that there is sufficient reason to believe that the very young may be more susceptible to central nervous system damage from arsenic exposure than are adults.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: No Evidence of Neurotoxicity (1)

Pennwalt Corporation states that the studies referred to in the PD-1 contribute nothing significant to whether the registration of arsenic acid should be continued.

Agency Response: The Agency agrees with the rebutter (Pennwalt) that the three studies described in PD-1 do not present an adequate basis for a rebuttable presumption against the inorganic arsenical pesticides on the basis of delayed neurotoxicity. The additional delayed neurotoxicity studies discussed in this document are also not sufficient to support a rebuttable presumption against arsenic on this basis. The available studies and other information do not provide adequate data to define a no-observable-effect level (NOEL) for delayed neurotoxicity in the species tested or in man. In most of the experimental studies, the rat was chosen as the test animal, even though this species is quite insensitive to the effects of arsenic because of its metabolic treatment of the chemical. Specifically, the metabolism of arsenic in the rat is unique because rat hemoglobin has a high affinity for arsenic. This affinity results in a low rate of distribution of arsenic in the tissues and hence a high arsenic tolerance. Other problems in the available data (e.g., the imprecise determination of dose levels) limit the usefulness and suitability of this information for predicting the delayed neurotoxicity potential of arsenic in man. However, particularly in view of the low sensitivity of the rat, the Agency still retains a concern that arsenic may have the potential to produce delayed neurotoxic effects in humans.

c. Summary of Rebuttal comments Concerning Neurotoxic Effects: Conclusion

In conclusion, the Agency has determined that from the above reviews which represent the currently available information on arsenic induced neurotoxic effects, insufficient data exist to allow for characterization of a quantitative human dose/effect relationship.

Further, there is not sufficient evidence for considering the use of arsenic in wood preservatives to be an unreasonable neurotoxic hazard. The Agency has determined that with the available data, the potential of arsenic to cause delayed neurotoxic effects cannot be estimated for either adults or young children.

6 Analysis of Rebuttal Comments About Human Exposure

a. Basis of Analysis

This analysis is based on comments made to rebut the October 1978 Notice of Rebuttable Presumption and on other information received since then. In general, these consisted of usually brief comments from farmers, state agency and industry representatives or individuals who have past or present interest in the use of inorganic arsenic as a wood preservative. Although these comments were not usually scientific in nature, they are welcome as a broad indication of experience with inorganic arsenic. The majority of views indicated few problems from the use of inorganic arsenic compounds. However, the chronic effects, such as cancer, would not likely be observed by these individuals. Since the nonwood uses of the inorganic arsenical compounds will be considered in another document, this analysis covers only those rebuttal comments regarding exposure from the wood preservative uses of arsenic.

The Agency reviewed a total of 229 rebuttal comments concerning exposure. Of these, 216 provided subjective information in support of the continued registration of the inorganic arsenical compounds. The remaining thirteen comments provided specific information and scientific evidence that attempts to show these compounds either are or are not a hazard to human health. One of the thirteen comments, one contended that the Agency underestimated arsenic residues on treated wood and air concentrations in treatment plants. No comments were directed to dietary arsenic exposure from wood treated with the inorganic arsenical compounds.

b. Analysis of Specific Rebuttal Comments

Rebuttal Comment 1: **Arsenic in Nature (10, 38, 50, 52, 60, 61, 75, 90, 97, 111, 113, 124, 121, 122, 123, 124, 132, 135, 145, 185, 187, 191, 203, 223-7)**

A number of rebutters stated that arsenic is ubiquitous in nature and does not biomagnify; therefore, the exposure of the public to wood treated with inorganic arsenical compounds does not pose a public health problem.

Agency Response: While it is true that arsenic is ubiquitous in the environment, biomagnification only concerns exposure through the food chains. Levels of this element in the air of wood treatment plants, wood treatment solutions and in treated wood far exceed natural background levels. In addition these natural background levels of arsenic include both organic and inorganic arsenic. Organic and inorganic arsenic compounds have different metabolic pathways and different human health effects, (Underwood, 1971; Frost, 1970).

Rebuttal Comment 2: Lack of Health Effects in Wood Treatment Workers (10, 38, 50, 52, 60, 61, 76, 90, 97, 111, 113, 120-4, 132, 135, 145, 185, 187, 191, 203, 223-7)

A number of rebutters claim that employees handling chromated copper arsenate (CCA) solutions and treated wood products have considerably higher exposure to arsenic than the general public. Nevertheless, these rebutters report no instances of employee sickness or ill-health due to handling these materials and that no customer complaints have been received. Several respondents indicate that these observations cover several decades of wood treatment activities. A number of industrial health or medical surveys or both have been conducted within several treatment plants.

A survey of 76 utility companies indicates only one report of skin irritation due to contact with arsenic-treated poles. No customer complaints were noted. One utility company which has used both CCA and ammoniacal copper arsenate (ACA) treated poles since 1954, reports no cases of oncogenic or mutagenic effects of handling these products by their employees.

Agency Response: The rebutters claim no cases of employee sickness and that no consumer complaints have been received. This is a subjective statement not documented by studies and does not take into account possible chronic exposure effects. Therefore the Agency rejects this comment.

Rebuttal Comment 3: Identity of Compounds of Concern (2)

AWPI states that tables 13 and 14 (PD-1, pp. 108-109) are in error; the arsenic in Table 13 should be listed as As_2O_5 (arsenic pentoxide) and in Table 14 for ACA, the As_2O_3

(arsenic trioxide) should be listed as As_2O_5. This error implies the use of trivalent arsenic in the listed wood preservatives whereas it should be pentavalent arsenic.

Agency Response. The Agency agrees with the rebutter. Labels frequently express arsenic as the common oxide. This does not mean, nor did the PD-1 intend to mean, that all the arsenic in the wood preservative products is trivalent. However the Agency recognizes that trivalent arsenic arsenic is occasionally used in ACA formulation that are mixed on site. During the mixing process the trivalent arsenic is oxidized to pentavalent arsenic.

Rebuttal Comment 4a: Arsenic is Fixed in Wood - Fixation (2, 10, 38, 50, 52, 60-1, 76, 87, 90, 97, 111, 113, 120-4, 125, 132, 145, 185,87, 191, 203, 223-7)

A number of rebutters contend that when wood is properly treated, the arsenicals form an insoluble bond with chemicals in the wood and, therefore, interact minimally with the environment.

The American Wood Preservers Institute (AWPI) and others claim that arsenical wood preservative chemicals, once the treated wood has undergone fixation, are in a highly stable, insoluble form that resists leaching. AWPI points out that these chemicals present unique exposure situations and that the

Occupational Safety and Health Administration (OSHA) exempted treated wood from its final arsenic work standard (29 CFR 1910.1018). AWPI claims that even though the fixation process is complex and the fixative used (chromic acid or alkali metal dichromate) determines the reactions involved, highly insoluble arsenate compounds are precipitated in the wood. The fixation process is detailed for CCA solutions in both AWPI Vol. I (p. 230-234) and Vol. III (p. 146-149), the latter being referenced in PD-1. This fixation phenomenon is presented and documented by AWPI (Vol. 1, ref. 363 and 407; Vol. III, ref. 1 and 245).

Agency Response: The Agency agrees with the rebutter that OSHA did indeed exempt treated wood from its "final work standard." However, it must be noted that the treated wood was not exempted on the basis of arsenic exposure concerns but rather that the wood is treated with a pesticide and treating wood is a pesticide application process and therefore covered under FIFRA.

In addititon, though arsenicals are said to be fixed in treated wood, leaching tests indicate the arsenical salts can be leached from the wood; surface residues as high as 24 mg As/ft^2 (PD-1, Table 21) have been measured for ACA-treated wood.

The fixation detail presented by AWPI, however, is sketchy for ACA and fluor chrome arsenic phenol (FCAP) solutions.

Additional data on the fixation of ACA solutions in wood were submitted by another rebutter (California Department of Health Services, #212). They found ACA surface residues of 2.7 to 23.1 mg/ft^2 versus 4.5 to 7.5 mg/ft^2 for CCA-treated wood indicating generally greater loss from the former. This indicates ACA fixation is not as durable as CCA; however, both formulations leach from the wood. The Agency continues to believe that dermal exposure to either ACA-and-CCA treated wood is a problem because these values submitted by the California Department of Health Services are higher than those reported earlier (PD-1, Table 17). Even though fixation does occur, it is apparent that surface residues exist and subsequent leaching, as well as blooming (post treatment migration of formulation to the surface) of the salts, can provide available arsenic for dermal exposure.

The review of the complexity of the fixation process and the reactions involved does show that the products are generally insoluble, and become physically bound or occluded to wood components; however, in-service durability reports indicate that slow leaching from wood products always occurs. Thus, although AWPI claims fixation holds the arsenic in the wood, leaching and dermal exposure to suface residues is not precluded even though most of the arsenic may be fixed chemically or physically.

Rebuttal Comment 4b: Arsenic is Fixed in Wood Leaching Tests (2)

AWPI contends that the Working Group misunderstands the leach-resistant character of treated wood and the significance of accelerated leaching tests (AWPI, Vol. 1, pp. 234-239).

AWPI (Vol. III, p. 149-151,), objects to the use of accelerated leaching tests to compare different preservative systems to indicate the relative efficiency of the fixation mechanism. AWPI claims that such accelerated leaching tests are not appropriate in attempts to extrapolate such short-term data to in-service products for human exposure.

AWPI (Vol. I, p. 234-239 and Vol. III, p. 149-151) claims that reports by Arsenault (1975), Lumsden (1964) and Gjovik and Davidson (1973), which report data from in-service tests, are a more appropriate measure to compare the fixation of arsenical preservative systems. Reports by Fahlstrom et al. (1967) and Henry and Jeroski (1967), (cited in AWPI, Vol I and III) indicate the leach resistance of the various preservatives to be CCA-A and B> CCA Type C> ACA and FCAP*.

Agency Response: Accelerated leaching tests measure the amount of arsenic leached from the treated wood as a result of repetitive rinsing of the wood with water. The Agency agrees with the rebutter that use of accelerated leaching tests is an atypical situation for measuring dermal exposure. Therefore the Agency has only used the accelerated leaching measurements for the flooded basement condition discussed under Rebuttal Comment 4c. The Agency used 0.529 mg/ft^2 of arsenic for its estimated arsenic surface residue level which could be removed by a hand, (Dreher 1974). The rebutter's comments are therefore not applicable to this issue.

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* Type A, B, and C refer to the relative amounts of arsenic chromimum and copper in the CCA formulations.

Rebuttal Comment 4c: Arsenic is Fixed in Wood - Flood Leaching from All Weather Wood Foundations (AWWF)(2)

The rebutter, AWPI, claims that all weather wood foundations stay dry even during adverse weather conditions and that the Agency overestimated the amount of arsenic per square foot that could be leached from the basement's wall surfaces. Also, the rebutter objects to conditions in which a basement would be flooded for 7 days, and calls the Agency's example of leaching after 28 days of flooding "unrealistic."

Agency Response: Although dermal contact with arsenic leached as a result of basement flooding is infrequent, basement flooding is a potential route of exposure. The Agency rejects AWPI's claim that surface arsenic levels after flooding would be 5.67 mg/ft^2. Data from the California Department

Health Services rebuttal submission #212 shows that treated wood, even without leaching, can have a surface residue of up to 4.5 mg/ft^2 of arsenic. The value used by the Agency in PD-1 Table 21 (summary of tables 17 & 18, the amount of arsenic in splinters, on the surface of treated wood, and the amount of arsenic which can be leached by water) of 43.2 mg/ft^2 is the lowest value listed in Table 21. This value of arsenic leached from the wood is not therefore in the Agency's opinion, unreasonable. Contrary to claims of fixation, it has been shown, as noted in Table 21, that arsenic is leached and is not permanently bound in treated wood. The use of 5.67 mg/ft^2 of arsenic removed from scrubbing the treated wood totally neglects the effects of osmotic pressure which will cause salts to leach into surrounding waters. Thus the Agency rejects the rebutter's comments and the exposure estimate will not be changed. The Agency does agree, however, that the 28-day flooding estimate is unreasonable and this estimate will be deleted.

Rebuttal Comment 5a: Surface Levels and Dermal Exposure

The California Department of Health Services claims that surface residues of arsenic have been underestimated. The data supplied by California show total arsenic surface levels from ACA treated wood of 2.7 to 23.1 mg/ft^2; in fact one sample reported by the rebutter was 90 mg/ft^2. CCA treated wood showed residues of 0.76 to 4.5 mg/ft^2. These values are considerably higher than the Agency's estimate of

0.529 mg/ft^2 for CCA treated wood. It appears that surface residues vary with treatment.

Agency Response: The Agency concludes that the data supplied by the California Department of Health Services are valid. The higher residue levels (CCA 4.5 mg/ft^2; ACA 23.1 mg/ft^2) will be used to estimate dermal exposure.

Rebuttal Comment 5b: Dermal Exposure - Lack of Dermal Absorption (2)

AWPI contends, based on the work of Hood *et al.* (1977), (see AWPI, Vol. 1 pp. 223-225), that the PD-1 dermal exposure should be negligible since Hood found essentially no arsenic absorption from CCA-treated sawdust applied, as a paste, to rabbit skin. This was confirmed by an independent laboratory analysis of rabbit blood which showed levels of less than 1 ppm of arsenic for both treatment and control animals; one rabbit had 2 ppm of arsenic in its blood (AWPI, Vol II, Appendix 6). Hood's study (1977) indicated that arsenic-treated wood was not a skin irritant, nor was there absorption of arsenic.

Agency Response: The rebuttal comment is rejected because irritation of the skin has occurred in common practice with arsenic-treated wood (California Dept. Health Services). The Agency assumes that irritation may be evidence of skin penetration. Further, the low levels of arsenic in the rabbits blood does not support the rebutters conclusion. The blood samples were taken nine days after the asenic exposure had ceased. This could provide ample time for any arsenic that might have been absorbed across the skin to be metabolized out of the body.

Rebuttal Comment 5c: Dermal Exposure - Short Duration of Dermal Contact (2)

AWPI (Vol. I, p. 15) contends that, although wetting a worker's hands with wood preservative solution is not impossible, it is unreasonable to assume that the worker will fail to wash his or her hands long before any significant amount of the relatively dilute brush-on arsenical solution is absorbed (AWPI, Vol. 1, p. 240). Such exposure would be negligible, due to work place practices (AWPI).

Agency Response: The PD-1 (p. 121) used 20 ml of apreservative solution applied to both hands as the highest estimate of dermal exposure for intermittent application of arsenicals to wood, with 10% being absorbed. Because of a study by Dow (Weaver, 1978)*, the Agency believes that 6 ml of solution is required to wet both hands and should be used in place of 20 ml. The Agency will also revise the 10% dermal absorption of liquids to 0.1% per Dutkiewicz, (Experimental studies on arsenic absorption routes in rats 1977). Furthermore, the Agency will revise the value of 10% dermal absorption for dry dusts to 0.01%. This is based on an extrapolation from the Dutkiewicz study on the absorption of aquaeous arsenic solutions.

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* It should be noted that this study was done on a woman's hand. Using 6 ml is, therefore, consistant with using the woman's 60 kg body weight.

Rebuttal Comment 6a: Respiratory and Related Exposures - Air Levels (212)

The California Department of Health Services provides data showing air levels around a wood preservative mixing site of 1.02 mg/m^3 arsenic. The TWA (time weighted average) from this data for arsenic in the air is 0.043 to 0.07 mg/m^3. The rebutter contends that the exposure is continuous rather than of short duration because samples were taken 12 feet from the mixing site.

Agency Response: The Agency agrees that the in-plant levels (up to 0.07 mg/m^3) should be used uniformly to estimate background inhalation exposure in large industrial situations. Activities which have higher inhalation exposures will use arsenic levels specific to the situation.

Rebuttal Comments 6b: Respiratory and Related Exposures - Breathing Rates (2)

AWPI claims the breathing rate used in PD-1 (1.8 m^3/hr) for heavy work is too high. They cite Altman (1958), who used a breathing rate of 0.98 m^3/hr. for light to moderate work and 1.47 m^3/hr. for heavy work.

Agency Response: The Agency agrees with the rebutter's comment because it is based on measured values. The Agency will revise its breathing rate estimate to 1.47 m^3/hr for heavy work, and to 0.98 m^3/hr for light to moderate work and 0.27 m^3/hr for a resting breathing rate per Altman (1958) in the exposure analysis. These estimates are only for women. Breathing rates for women are being used because inorganic arsenic compounds have teratology and fetotoxicity concerns. It should be noted however that in the exposure analysis, a lower breathing rate and less body weight result in less than 10% difference in arsenic exposure between women and men.

Rebuttal Comment 6c: Respiratory and Related Exposures - Intestinal Absorption of Nonrespirable Particles (2)

AWPI claims that the Agency erred in its initial assumption that arsenic in particles of wood that pass into the gastro intestinal (GI) tract will be absorbed to the extent of 75%. They cite Peoples (1977) who found that only 40% of arsenic fixed in CCA-treated sawdust was absorbed, since 60% of the pentavient arsenic fed to the dogs was excreted in the urine.

Agency Response: The Agency will change its estimate of GI tract absorption from 75% to 40% because the 40% is based on a documented study and the 75% was an assumption. This is true however, only for large particles such as sawdust. The original estimates for small particles remains unchanged. Small particles and vapors reach the deep parts of the lung where they are absorbed into the blood or lymph and are subsequently translocated to the other parts of the body. Small particles can stay suspended in inspired air and are subsequently exhaled. The percent absorption may range from 10 to 100% of the amount inhaled. The larger particles (those greater than 10 microns in diameter) are either filtered out by the turbinates in the nose or are deposited in the pharynx, trachea, or larger bronchi. Material deposited in these places is removed by ciliary action and the material is gradually moved to the back of the mouth where it is swallowed or spit out. If it is swallowed, oral exposure occurs in addition to inhalation exposure.

Rebuttal Comment 6d: Respiratory and Related Exposures - Inhalation of Arsenic in Wood Particles (2)

The AWPI comments that PD-1 assumes 1), a router operation (furrowing and gouging out of wood) presents the same exposure as any other mechanical cutting operation and, that 2), the test data (PD-1 p. 123, Table 1) only establishes 50% of the potential exposure. Both of the above assumptions are erroneous.

The sawing operations data (p. 249, Vol., 1. AWPI Rebuttal) are the only realistic and reasonable method to calculate potential exposure for making a risk/exposure analysis and subsequent regulatory decision.

Also, PD-1 incorrectly assumes that 25% of the airborne particles will be respirable and that 100% of the arsenic reaching the lung will be absorbed, (Dinman, 1978).

Agency Response: The example in PD-1 stated the initial assumptions for estimating exposure from sawing and handling wood. Using a router, according to the rebutter, is unlikely. Although wood used for outdoor signs or other outdoor wood uses may be treated and a router used on these materials, the Agency recognizes this is not typical of sawing operations. The Agency also agrees with the rebutter that doubling the wood particles in the air due to router operations is without merit.

Furthermore the Agency agrees with the rebutter that sawing operations should be used to calculate exposure to arsenic-treated wood, but will use the highest value (0.36 mg/m^3) from sawing operations as shown in PD-1 (page 123) Table 16;

(arsenic concentrations in air during cutting and building operations) for exposure calculation resulting from electric saw cutting of plywood. The rebutter supplied information (AWPI Vol. III, 236) that only 5.3% of the arsenic-containing dust from sawing operations was respirable and assumed that a value of 10% would account for possible variations. The Agency agrees with this approach at this time and will use a 10% respirable rate for arsenic-containing particles resulting from sawing.

The Agency disagrees with the rebutter's claim that only 40% of the respirable fraction will be available for lung absorption. The work of Dinman (1978) was based on a calculation of dead space volume in the lungs and does not take into account nasal passages or turbulent mixing in the respiratory system. The Agency will continue to use 100% absorption until evidence to the contrary is presented.

Rebuttal Response 6e: Respiratory and Related Exposures - Invalid Reliance on "Worst Case" Assumptions (2)

The AWPI contends that the PD-1 grossly exaggerated the level of exposure that could reasonably be anticipated on a "worst case" basis. As a result of the high exposure estimates, PD-1 severely underestimated the true margin of safety.

AWPI claims that inhalation exposure is lower than that estimated by the Agency in PD-1. In addition negligible dermal exposure occurs in large scale treating plants. One of the basic differences is the Agency's use of an arsenic air concentration of 0.22 mg/m^3, the highest value observed by Arsenault (1976), as a maximum exposure level for a plywood stacker. This value, AWPI states, is clearly high when compared with other similar exposure situations, i.e., 0.002 mg/m^3 for stacking lumber versus the 0.22 mg/m^3 for stacking plywood used by the Agency. Additional information in the same set of data shows a concentration of 0.01 mg/m^3 for stacking plywood. AWPI points out that a plywood stacker had a urinary excretion level of 94 mg/liter of arsenic. Pinto et al. (1976) found by experiment that the inhaled airborne arsenic level in ug/m^3 was equal to 0.304 times the urinary arsenic level in mg/liter. Calculating from a plywood stacker's urinary concentration of 94 mg/liter into a theoretical air concentration, the arsenic in air would be 0.03 mg/m^3.

Agency Response: The Agency agrees that 0.22 mg/m^3 is an unlikely value. The Agency agrees with another rebutter (California Department Health Services) who provided data showing air concentrations of arsenic of 0.043 to 0.07 mg/m^3 measured in the industrial setting adjacent to mixing of the treatment solution. The value of 0.07 mg/m^3 is slightly above the value obtained by Arsenault (0.05 mg/m^3) for areas near the mixing of the preservative solutions. The Agency will use 0.07 mg/m^3 as a general industrial inhalation exposure value.

Rebuttal Comment 61: Respiratory and Related Exposures - Inhalation exposure to persons living and/or working in dwellings containing arsenic-treated wood (2)

AWPI contends that using an arsenic air concentration of 3.6 ug/m^3 as reported in the National Concrete Masonry Association, NCMA, (1976), but not consistant with Sleater and Berger (National Bureau of Standards, (NBS) 1977) or Williams (1978), does not represent a fair analysis of potential exposure in homes with arsenic treated wood. Using the highest level of 0.031 ug/m^3 of arsenic, as reported in both the Sleater and Berger (1977) and Williams (1978) studies, would be more appropriate.

Agency Response: The NCMA (1976) study of two homes indicated interior airborne arsenic levels of 0.6 and 3.6 ug/m^3 while the Sleater and Berger, NBS, (1977) study of 10 homes gave values ranging from 0.002 to 0.031 ug/m^3. The latter study could not explain the 116 to 300-fold higher values found in the NCMA study. Both studies monitored two of the same homes; the NCMA study showed a 32 to 300-fold higher level in one home and a 277 to 1800-fold higher level in the other than the Sleater and Berger study. The NBS study showed average outside air arsenic values of 0.002 ug/m^3 as a control. Both studies sampled for particulates using high volume air samples with filters and the same analytical methodology. Williams (1978) monitored 3 homes with CCA-C treated wood and found values of 0.001 to 0.029 ug/m^3 with an average air level of 0.021 ug/m^3, which is similar to the NBS study. It is apparent from Tables 19 (arsenic in air of buildings constructed with wood pressure-treated with arsenical wood preservatives) and 20 (arsenic in dust of homes containing arsenic-treated wood) of PD-1 that arsenic levels, in general, were lower in those cases where treated plywood was covered rather than exposed.

Both PD-1 and AWPI (Vol. I) speculate on reasons for the wide variation in measured arsenic air concentration values reported in these studies, all of which are possible explanations for the observed concentration variations, but does not resolve the issue. Such explanations include: 1) thorough cleaning of the homes; 2) arsenic from exterior soil; 3) home use of arsenical pesticides; and 4) sample contamination.

The Agency dismisses the high values from the NCMA (1976) study as aberrant and will utilize the highest value of Sleater and Berger (1977) of 0.031 ug/m^3 for exposure calculations because the data is based on a larger number of homes. The larger sample of homes (10) provides similar results for each home and is considered more reliable than results based on only two homes. The discrepancy in data, however, remains unresolved.

The AWPI rebuttal did not discuss the dust sampling data in the NCMA (1976) and NBS (1977) studies. However, the Agency has decided that the same rational applies to these samples. The NBS (1977) study reported levels of 2-1267 ppm of arsenic in house dust, with the higher levels reported in houses in which the treated wood was exposed. Since the NBS (1977) study reported analytical data for eleven dust samples, compared to two samples in the NCMA (1976) study the Agency has determined that the NBS data are a better measure of actual levels in household dust. Thus the highest value reported, 1267 ppm, will be used in the exposure analysis.

In addition to the NCMA and NBS studies, the AWPI submitted an additional home air and dust monitoring study. The values reported in the AWPI study were similar to the lower range of values reported in the NBS study. Table II.C-3 presents a summary of the arsenic air and dust monitoring data from homes containing arsenic treated wood.

Table II.C-3

Arsenic in Homes with All Weather Wood Foundations (AWWF)

Location	NCMA	NBS	AWPI
Inside Air (ug/m^3)	600-3600	0.002-0.031	0.001-0.004
Outside Air (ug/m^3)	-	0.002-0.005	0.001-0.004
House dust (ug/m^3)	-	2-1267	2.3-5.6
Soil near home (ug/gm)	-	3-6	1.5-9.9
Home Samples	2	10	3

Rebuttal Comment 7: Closed Treatment Systems Reduce Exposure to Negligible Levels (2, 10, 38, 50, 52, 60, 76, 90, 97, 111, 113, 120-4, 132, 135, 145, 185, 187, 191, 203, 223-27)

A number of rebutters contend that most wood treatment uses of arsenic involve a chromated copper-arsenate (CCA) type preservative. The treatment process involves a closed system, largely automated, so that employees have minimal exposure to toxic chemicals. Employees who may be exposed are provided with protective work clothing and facilities for maintenance of personel hygiene. Very little preservative residue is left on the treated wood because the excess treating solution is drawn off and prefiltered for return to the treatment storage system. Employees have little or no physical contact with freshly treated wood and consumers receive only air or kiln-dried materials.

Agency Response: The Agency recognizes that CCA treatment in modern, closed-system plants provides some protection to the worker from inhalation and dermal exposure. However, use of ammonia-copper arsenic (ACA) and fluor-chrome-arsenic-phenol mixtures (FCAP) generally involves batch preparation on site. This is also true of some CCA treatment plants.

In such cases, dermal and inhalation exposure to workers can occur during the mixing process. This is shown in Table 15 of the Position Document 1, listing exposures to workers. Subsequent handling of the wood, which is not dry after treatment, can result in dermal exposure. The rebuttal comments claim protective clothing is used where exposure situations occur, but this is not a documented or required practice.

In a study by Klemmar _et al_. (1975) arsenic in house dust in homes of employees working in the wood preservatives industry was measured and values up to 1,080 ppm were obtained. From this information, the Agency concludes that use of arsenic wood preservatives provides an exposure source far above background levels.

Rebuttal Comment 8: Use of Liquid Formulations Reduces Exposure to Negligible Levels (2)

The AWPI claims that dry powder formulations are no longer in significant use and that over 90% of the CCA concentrate used currently is in liquid form mostly handled in closed-system operations.

Agency Response: AWPI (Vol. III, p.9) does indicate that a powdered CCA formulation is used by a few treaters, but they mention nothing of the fluor chrome arsenic phenol (FCAP) treatment, which is a powder formulation. Also, ACA can be made up by powder formulation and with FCAP accounts for 10% of the wood preservative formulations. AWPI claims insignificant use of dust formulations and assumes minimal exposure because of protective clothing, but these claims cannot be substantiated from the information provided. The Agency agrees that a closed system operation, in the case of CCA, greatly reduces exposure potential. AWPI claims that when potential exposure to arsenical wood concentrate is present, plant workers are provided protective equipment, however, AWPI does not state that this is a required practice. In summary, the rebutter claims that exposure to treatment solutions is negligible, but based on the information given, exposure to arsenic-containing treatment solutions is still considered likely to occur.

Rebuttal Comment 9: Agency Did Not Consider Chronic or Repeated Exposure or Special Hazards to Children (212)

The Department of Health Services for the State of California claims that the Agency failed to consider chronic or repeated exposures or the special hazard to children from playing on playground equipment made from treated wood.

Agency Response: The chronic or repeated exposure is taken into account when estimates of exposure (including length of exposure) are presented in the oncogenic, mutagenic and teratogenic human Risk Analysis PD 2/3, Part II.C.8 The rebutter's point concerning the special hazard to children is well taken. Children could conceivably be more affected because of their lower body weight and direct oral and dermal contact with wood. However, at this time the Agency has determined that with the available data the exposure of children to the end uses\of the treated wood (playground equipment) cannot be estimated.

c. Summary of Rebuttal Comments and Revised Assumptions

Many points were raised by rebutters with regard to data used to determine exposure. In many cases the data were a valuable aid to the Agency in revising its original assumptions on exposure. Much of the evidence considered valid will be used in this position document. In other cases, where the data conflicted with other evidence, the highest reasonable exposure data were used. Evidence presented that appeared inadequate or questionable was rejected.

In the consideration of the revised exposure information presented in the exposure rebuttal analysis, the Agency has determined that these comments on exposure do not rebutt the human health effects described in Part II.C-2, 3, and 4 of this document.

The following is a summary of changes that the Agency has made in the exposure estimates.

1. The estimated breathing rate has been lowered from 1.8 m^3/hr to 1.47 m^3/hr for women doing heavy work and from 1.8 m^3/hr to 0.98 m^3/hr for women doing light work.

2. The resting breathing rate for women is 0.27 m^3/hr.

3. The estimate for GI tract absorption of arsenic is lowered from 75% to 40%.

4. Inhalation exposure for plywood stackers and other industrial situations has been lowered from 0.22 mg/m^3 to 0.07 mg/m^3. In-plant use of arsenic can produce arsenic air concentrations of 0.043 to 0.07 mg/m^3. The higher value will be used to estimate industrial exposure.

5. The quantity of liquid used to wet both hands has been reduced from 20 ml to 6 ml.

6. Surface residue estimates on treated wood are increased from 0.529 mg/ft^2 for CCA and ACA to 4.5 mg/ft^2 for CCA and 23 mg/ft^2 for ACA.

7. The example of dermal exposure to a person cleaning a basement made with arsenic-treated wood after a 28-day flooding occurence, has been deleted .

8. The arsenic air concentration resulting from sawing operations is now estimated at 0.36 mg/m^3. The previous estimate was 1.4 mg/m^3.

9. The arsenic air concentration in homes constructed with arsenic-treated wood is now estimated at 0.031 ug/m^3. The PD-1 estimates ranged from 0.002 ug/m^3 to 3.6 ug/m^3.

10. The amount of respirable arsenic-containing dust from sawing operations has been reduced from 25% to 10%.

11. The dermal absorption of a liquid has been reduced from 10% to 0.1%. The dermal absorption caused by contact with dry dust will be 0.01%.

12. No conclusions can be drawn regarding the extent of dietary exposure from the use of inorganic arsenic as a wood preservative.

7. Revised Human Exposure Analysis

a. Introduction

In view of comments and other information received by the Agency since the publication of the initial presumption, the Agency has revised some of the initial presumption exposure estimates. It must be emphasized that a complete data base on which to base quantitative estimates of dietary exposure is still lacking. The Agency has made a number of assumptions concerning air concentrations, dermal absorption, and wood surface residue levels and human uptake of these residues. This analysis presents these revised non-dietary exposure estimates and those original estimates which remain unchanged.

b. Summary of Breathing Rate Assumptions

In general, the original exposure estimates for industrial use practices remain as described in PD-1. However, due to teratology and fetotoxicity concerns, the breathing rates and the body weight of the exposed person used in the calculations of exposure have been changed to reflect the potential toxic effect on women of child-bearing age; values of 0.98 m^3/hr for light work and 1.47 m^3/hr for moderate or heavy work will be used. For men, the corresponding breathing rates are assumed to be 1.2 m^3/hr and 1.8 m^3/hr. The resting breathing rates for men and women are 0.5 and 0.27 m^3/hr respectively, Altman et al. (1958). The body weight of a woman of child-bearing age is taken to be 60 kg.

c. Discussion of the Data Range of Assumptions

i. Inhalation - Industrial Situation

The range of air concentrations for arsenic in the large scale industrial setting ranged from 0.001 to 1.02 mg/m^3. The former value is listed in PD-1 (p. 114), and the latter value is from the California Department Health Services rebuttal submission (212). The "time weighted average" (TWA) for the California rebuttal was 0.07 mg/m^3 arsenic in air (corresponding to

0.010 mg/kg/day exposure). This estimate was judged to be a more representative measure of general inhalation exposure potential for industrial settings than the one value of 0.22 mg/m^3 found during plywood stacking (listed in PD-1 Table 15 Arsenic in Air During Treatment and Handling of Wood).

ii. Dermal - Industrial Situation (dust)

On page 117 of PD-1, the Agency made several assumptions about dermal exposure to dust formulations. The Agency estimated that a worker could contact 10 grams of dust per each exposure incident. Since no experimental data are available, no range of variation can be given. No rebuttal comments addressed this point.

iii. Dermal - Industrial Situation (Concentrate Treatment Solution)

The Agency originally estimated a worker could contact 20 ml of arsenical treatment concentrate on two hands. This estimate has been lowered to 6 ml (see Agency response to rebuttal comment 5c). The amount of arsenic is calculated on the basis of the arsenic content in this treatment concentrate solutions and is unchanged. This is the only data point available so no range is given.

iv. Dermal - Industrial Situation (Dilute Treatment Solution)

The Agency originally estimated a worker could contact 20 ml of dilute arsenical treatment solution. This was revised to 6 ml in light of rebuttal comments (see Agency response to rebuttal comment 5c). This is the only data point available, so no range is given.

v. Dermal - Intermittent Application to Wood (Non-Pressure Application)

The Agency assumes that a worker will contact 6 ml of treatment solution. No range is given (see Agency response to rebuttal comment 5c). Inhalation exposure was judged to be negligible because this is a small volume outdoor application and it is assumed that arsenic disperses rapidly in air.

vi. Dermal - Handling Treated Wood

The Agency originally estimated exposure based on a construction worker handling 1728 ft^2/day of treated wood out of which he will contact 15% of the surface area. The PD-1 used 0.529 mg/ft^2 as an estimate of the surface residue. PD-1 also assumed that the hand will remove all the residue and 10% will be absorbed.

A rebuttal by the California Department Health Services (212) objected to the use of this surface residue level

(0.529 mg/ft^2). The California Department of Health Services data indicate values of 0.14 to 4.5 mg/ft^2 for CCA-and 2.7 to 23.1 mg/ft^2 for ACA-treated wood. Some values for ACA treatment reached 90 mg/ft^2, and 8 of 20 samples exceeded 14 mg/ft^2. In case of CCA, 3 of the 7 samples exceeded 0.75 mg/ft^2. Because the Agency estimates are conservatively predicated toward the higher estimate, the highest residue levels of 4.5 and 23.1 mg/ft^2 for CCA and ACA respectively were used in the final exposure assessment. The same assumptions (see above discussion) about skin contact are still made, but the estimate of dermal absorption of dust has been revised to 0.01% based on an extrapolation of data by Dutkiewicz (1977).

vii. Inhalation - Handling and Sawing Treated Wood

In PD-1 the Agency assumed that workers involved in related sawing activities would be exposed to air concentrations of 1.4 mg/m^3 arsenic and that 75% of the arsenic present in inhaled sawdust would be absorbed into the gastrointestinal tract. These estimates have been lowered. The air concentration is now assumed to be 0.36 mg/m^3, based on industrial exposure measurements, and measurements made during sawing and fabrication of arsenic treated wood. The gastrointestinal tract absorption is assumed to be 40%, based on a study of the ingestion of arsenic-containing sawdust by dogs. If sawdust particles are large, and therefore not inhaled, inhalation exposure is assumed not to occur. Inhalation absorption in the lungs is still estimated at 100%.

A lower value of 0.01 mg/m^3 arsenic in air measured during handling of treated wood would yield an exposure dose of 0.001 mg/kg/day for combined gastrointestinal tract and inhalation absorption. The Agency dose estimate of 0.037 mg/kg/day used in the current exposure analysis reflects lowered exposure estimates based on arsenic air measurements, but still retains the highest reasonable estimate for this situation.

viii. Inhalation - Residents in Homes with Treated Wood

From two studies (National Concrete Masonry Association, (NCMA), and the National Bureau of Standards) listed in PD-1 and one study (AWPI) submitted post PD-1, data are available on the air concentration in homes built with arsenic treated wood. The Agency chose 0.031 ug/m^3 as the highest reasonable estimate for arsenic air concentrations in homes. Study values as low as 0.002 ug/m^3 were observed by the NBS and AWPI, while the highest arsenic value reported was 3.6 ug/m^3 (NCMA). This high value was rejected on the grounds that it was one of only two samples from the NCMA study and the NCMA data were inconsistent with the data in the National Bureau of Standards and the AWPI study, which had a sample size of 10 and 3 respectively. The resulting range is 0.002 ug/m^3 to 3.6 ug/m^3 arsenic; 0.031 ug/m^3 was selected because it was the highest value of the 10 samples (see Table II.C-3).

ix. Dermal-Flood Assumptions

For house cleanup after flooding, the Agency used a single data point of 43.2 mg/ft^2 of arsenic leached over a 7-day period. This is the only data point available and no range is given.

x. Dermal - Residents in Homes with Treated Wood (Dust)

In the case of exposure to dust containing arsenic in homes made from arsenic treated wood, the Agency used 1640 ppm in PD-1 as the highest reasonable estimate for arsenic containing dust. The lowest value obtained was 2 ppm. This is a wide range, and use of the higher value was not rebutted.

However, the value of 1640 ppm was from the NCMA study. The Agency has decided to use another study by the NBS (see rational in exposure rebuttal comment 6f) however for determination of both arsenic and and dust levels in homes using treated wood. Thus the highest value reported, 1270 ppm is used in the exposure analysis.

Table II.C-4 summarizes the range of available exposure data used in the exposure assumptions.

TABLE II.C-4

ARSENIC EXPOSURE DATA AND CORRESPONDING DOSES

Use Pattern	Parameter	Exposure Data Ranges	Data Used	Dose mg/kg/day Dose Ranges	Dose mg/kg/day Dose Used
Lrg. Scale Industrial Conditions	Inhalation	0.001 - 1.02 mg/m^3	0.07 mg/m^3	0.0002 - 0.204	0.010
	Dermal Dust (bag) opening	no range, assumed value	10 gms	no range, assumed value	0.0016
	Dermal treatment concentrate	no range, one data point	6 ml	no range, (one data point)	0.027
	Dermal Dilute Solution	no range, one data point	6 ml	no range, (one data point)	0.0017
Brush-on Application to wood (Non-pressure)	Dermal Contact	no range, one data point	6 ml	no range, (one data point)	0.003
Handling Treated Wood (sawing)	Dermal CCA	0.14 - 4.5 mg/ft^2	4.5 mg/ft^2	0.00006 - 0.002	0.002
	ACA	2.7 - 23.1 mg/ft^{26}	23.1 mg/ft^{2f}	0.0012 - 0.04	0.010
	Inhalation	0.01 - 0.36 mg/m^3	0.36 mg/m^3	0.0001 - 0.037	0.037
Residents in Homes with Treated Wood	Inhalation	0.001 - 3.6 ug/m^3	0.031 ug/m^3	3×10^{-6} to 1×10^{-3}	9×10^{-6}
	Dermal (flood cleanup)	no range, assumed value	43.2 mg/ft^2	one data point	0.0026
	Dust	2 - 1640 ppm	1267 ppm	2.1×10^{-5} to 2.1×10^{-8}	2.1×10^{-5}

d. Revised Human Exposure Analysis for Specific Exposure Situations

i. Exposure in Large-Scale Industrial Situation

The revised inhalation dose for a treatment plant worker (assuming 2 hours heavy exercise and 6 hours of light excerise) calculation is:

(Arsenic Air Conc.) x (breathing rate) x (length of time)
(wt of person) = exposure
0.07 mg/m^3 x 1.47 m^3/hr x 2 hr/day / 60 kg + 0.07
mg/m^3 x 0.98 m^{3}hr x 6 hr/day/60 kg = 0.010 mg/kg/day

0.07 mg/m^3 = in plant arsenic air concentration
1.47 m^3/hr = breathing rate moderate exercise
60 kg = weight of person
0.98 m^3/hr = breathing rate light work
0.010 mg/kg/day = in plant inhalation exposure

The Agency assumes dermal exposure is probably negligible in cases where closed systems are used for wood treatment. During mixing of the concentrate, however, a worker could wet both hands with the concentrated treatment solution which contains 27% arsenic. The Agency has determined that the volume of liquid that might come in contact with the skin is 6 ml. (see rebuttal comment 5c). Therefore the dermal dose for a worker mixing a concentrated arsenical treatment solution has been recalculated:

0.09 mg/kg/day arsenic reaching the body (PD-1 exposure estimate with corrected revised dermal absorption) x 6/20, or 0.027 mg/kg/day

0.09 mg/kg/day = amount of arsenic reaching the body from contact with a 27% arsenical treatment solution.

6/20 = correction factor for the change from 20 ml to 6 ml

0.027 mg/kg/day = dermal arsenic dose from mixing concentrated treatment solutions

Similarly, the original exposure estimate for dermal exposure to the diluted treatment solution containing 1.7% arsenic during handling of wet wood has been reduced by the factor 6/20, and the revised dose is:

0.0057 mg/kg/day arsenic reaching the body x 6/20
= 0.0017 mg/kg/day

0.0057 mg/kg/day = amount of arsenic reaching the body from contact with a 1.7% arsenical treatment solution (using revised dermal absorption rates)

6/20 = correction factor

0.0017 mg/kg/day = dermal arsenic dose from mixing dilute treatment solutions

In addition the Agency estimated the dermal dose from arsenic powder or dust formulations (bag emptying) and for dusts containing arsenic as 0.0016 mg/kg/day:

> 959 mg (PD-1 dust exposure estimate) x .0001 (revised dust dermal absorption) = .0959/60 kg = 0.00159 or 0.0016 mg/kg/day

959 mg = mg of arsenic dust contacting the worker estimated in PD-1

0.0001 = 0.01% arsenic dermal absorption

0.0016 mg/kg/day = dermal arsenic dose from bag emptying

It should be emphasized that the Agency still has little information on the magnitude of this dermal exposure. These calculations reflect the Agency's judgment that such exposure is likely to occur; the actual magnitude of this type of exposure clearly could vary widely, depending upon particular work practices and the care that individual workers exercise.

Another route of exposure to arsenic from the industrial use of wood preservatives appears to be contamination of household dust with arsenic. High levels of arsenic have been found in dust in treatment plant workers homes. These homes did not contain arsenic-treated wood (Klemmer et al., 1975); no rebuttal comments were received on this issue. Although there is apparently no way to quantitatively estimate the human exposure from this source, it remains another route which may contribute to the overall arsenic exposure.

ii. Brush-On Non Pressure Application of Inorganic Arsenicals

As discussed in PD-1 inhalation exposure during this use practice is considered to be minimal. Further no rebuttal comments were received on this point.

Potential dermal dose for this use practice is estimated using the same revised assumption concerning skin contact (6 ml) as was used for the mixing exposure estimates. Thus the revised dermal dose is 0.66 gms arsenic (PD-1) x 6/20 x (0.001) (dermal absorption for liquids)= 0.0198 mg/60 kg = 0.003 mg/kg/day

0.66 gms = amount of arsenic reaching the body (PD-1 exposure estimate)

6/20 = correction factor

0.001 = revised dermal absorption for liquids, 0.1%

60 kg = weight of person

0.003 mg/kg/day = amount of dermal arsenic exposure from brush on or non-pressure treatment applications

iii. Exposure from Handling/Sawing of Arsenic-Treated Wood

The exposure estimates listed in the PD-1 have been revised downward. The estimated sawdust concentration in the air has been revised because better data on actual dust concentrations was provided by the rebuttals (AWPI). Also, the breathing rate for women has been lowered to 1.47 m^3/hr for moderate or heavy work and the gastrointestinal absorption rate has been lowered from 75% to 40% (Peoples, 1977). These revisions are reflected in the new exposure estimates presented below.

Exposure via Lung Absorption for Handling and Sawing Treated Wood is:

> 0.36 mg/m^3 arsenic air concentration from sawing plywood x 1.47 m^3/hr (moderate work) x 8 hr/day x 0.1 (respirable fraction of sawdust)/60 kg = 0.007 mg/kg/day

Exposure via gastrointestinal tract for Handling and Sawing Treated Wood is:

> 0.36 mg/m^3 x 1.47 m^3/hr x 8 hr/day x 0.4 (40% GI absorption factor) x 0.9 (remaining fraction of non-respirable sawdust) / 60 kg = 0.03 mg/kg/day

The total inhalation dose is the sum of the two above calculations or 0.037 mg/kg/day

For dermal exposure from handling treated wood, the estimate has been changed. The estimated surface residue for CCA-treated wood is now 4.5 mg/ft^2 and 23 mg/ft^2 for ACA-treated wood. The Agency assumes, a construction worker will typically be involved in carrying, positioning, and nailing treated plywood in the construction of dwellings. Further, the Agency assumes the worker will work with 4 x 8 foot plywood sheets (32 ft^2), position and nail 7 sheets/hr, and will contact 15% of the surface area during these activities. If the work day is 8 hours, then the worker will contact (32 ft^2 x 7 sheets/hr x

8 hr) x 0.15 (15% surface) or 268 ft^2/day. Using these estimates, dermal dose is calculated:

CCA 4.5 mg/ft^2 x 268 x 0.01% (revised dermal absorption factor)/60 kg = 0.002 mg/kg/day

ACA 23 mg/ft^2 x 268 ft^2 x 0.01% (revised dermal absorption factor) / 60 kg = 0.010 mg/kg/day

Because of lack of data on FCAP residues, wood treated with FCAP (Fluor-Chrome-Arsenic-Phenol) is assumed to have residues similar to ACA.

iv. Exposure to Persons Living/Working in Dwellings Containing Arsenical Treated Wood (All Weather Wood Foundations, AWWF)

The conflicting reports by the NCMA (National Concrete Masonry Assn., 1976) and the MBS (National Bureau of Standards, 1977) and (AWPI, 1980) presents an unresolved question as to the quantitative estimate of the arsenic concentration in air in dwellings containing AWWF basements (basements constructed with treated wood). The Agency reviewed the wide range of values (3.6 ug/m^3 to 0.001 ug/m^3) and selected 0.031 ug/m^3 because it is based on a sampling of a large number of homes and the variation between the homes samples is low. Using the NBS highest value of 0.031 ug/m^3 the following revision in the inhalation dose estimate is calculated:

$0.031\ ug/m^3 \times 0.98\ m^3/hr$ (light work) x 16 hr + $0.031\ ug/m^3 \times 0.27\ m^3/hr$ (resting) x 8 hr / 60 kg = 0.0094 ug/kg/day or 0.000009 mg/kg/day

In PD 1 the Agency estimated the dermal exposure of homeowners to arsenic-containing house dust. It was assumed for this estimate that homeowners can be dermally exported to 10 grams of house dust during sweeping, that the arsenic level in the dust could be as high as 1640 ppm, and that 10% of all arsenic will be absorbed through the skin. Based on revisions to these estimates discussed in the rebuttal analysis, the revised dermal exposure estimate is as follows:

$$1{,}267 \text{ ppm X } 10\text{g dust X } 0.01\%/60\text{Kg} = 2.1\text{x}10^{-5} \text{ mg/kg/day}$$

Dermal exposure can also occur from the cleanup of flooded basements constructed with AWWF's. The Agency has determined that the original assumptions of continuous flooding for 28 days is unlikely and therefore this exposure estimate has been deleted. The estimate for 7-day flooding however, has been retained because dermal exposure can occur from cleaning up such basements. Thus, the estimated dermal dose for the 7-day flooding is 26 mg/kg/day arsenic reaching the body x .01% (revised dermal absorption) = .0026 mg/kg/day.

e. Summary

Table II.C-5 provides summaries of the calculated exposures and doses, including those that the Agency has revised, and the unchanged calculated exposures presented in PD-1. The use patterns discussed, correspond to those presented in the PD-1. The large scale industrial situations apply to workers treating utility poles, lumber and timber, pilings, crossarms, posts and to dermal exposure from handling wet wood.

The brush-on intermittent exposure estimates apply to non-pressure application of arsenic-containing treatment solutions on lumber and timber, posts, utility poles, crossarms and pilings. The category for handling treated wood includes sawing/fabrication for inhalation exposure; the dermal exposure includes the estimated residues a to which worker may be exposed as a result of handling the dry treated wood. The exposure to persons in dwellings is presented in two parts: 1) the inhalation and dermal exposure to arsenic containing dust in homes using the treated wood, 2) estimated dermal exposure resulting from cleanup of a flooded basement (7 day flood). The exposure estimates to persons in dwellings apply only to lumber/timber. Included in the lumber and timber category are all weather wood foundations (AWWF's)and treated plywood and poles used in barn construction.

TABLE II.C-5

Revised Total Daily Body Dose Calculations for Inorganic Arsenicals

	Absorption (i) %	Dermal Dose mg/kg/day	Daily Inhalation[j] Dose mg/kg/day	Gastro Intestinal Exposure mg/kg/day	Gastro Intestinal Dose mg/kg/day	Total Daily Dose mg/kg/day
I. Large Scale Industrial Use						
a. Plant[a] Arsenic Air Level	-b	-b	0.010	NA	NA	0.010
b. Bag[c] Emptying (Dust)	0.01	0.0016	0.015	NA	NA	0.017
c. Mixer[d] Concentrate	0.1	0.027	0.010	NA	NA	0.037
Mixer Dilute Sol'n	0.1	0.0017	0.010	NA	NA	0.012
d. Handler[a] (wetwood)	0.1	0.0017	0.010	NA	NA	0.012
II. Brush-on[a] Application Non-Pressure	0.1	0.003	-e	NA	NA	0.003
III. Handling, Sawing[a,b] Fabrication (Dust)	0.01	CCA ACA 0.002 - 0.010	0.007	0.075	0.03	CCA ACA 0.039 to 0.047
IV. Resident in As[g] Treated Homes	0.01	0.000021	0.000009	NA	NA	0.00003
V. Flooded Basement[h]	0.01	0.0026	-	NA	NA	0.0026

a. Daily dose calculated assuming an 8-hour work day.

b. The dermal exposure for an individual who does not directly contact treated wood or formulations (e.g., supervisors) is believed to be insignificant relative to that individual's inhalation exposure. In addition, reliable estimates of dermal exposure for such personnel are not, at present, possible.

c. Bag emptying operations are assumed to occur, at most, for 20 minutes in an 8 hour day. Dermal exposure estimates are based on this 20-minute exposure in addition to a 7-hours 10-minutes exposure to background air levels of arsenic.

d. Dermal exposure estimates are based on a presumed spill during which both hands of the mixer are covered with the arsenic formulation. Inhalation estimates assume 8 hours of exposure to the background level of arsenic.

e. Inhalation exposure during such application is assumed to be negligible since the formulations are applied as a viscous liquid and not as a spray.

f. Estimates were developed on the basis of arsenic levels in air while sawing arsenic-treated wood. It is assumed that 10% of the arsenic-containing dust will be respirable and that the remaining non-respirable dust (90%) will enter the gastrointestinal tract. It is also assumed that 40% of this material is absorbed in the gastrointestinal tract.

g. Based on a 24 hour exposure.

h. Based on an 8 hour exposure to arsenic dust following flooding of a basement constructed of arsenic-treated wood. Such flooding is assumed to occur no more than once in 70 years.

i. The dermal absorption estimate was originally estimated at 10% for liquids and dusts, the revised estimate is now 0.1% for liquids an 0.01% for dust.

j. Inhalation rates have been revised from 1.8 m^3/hr, to 1.47 m^3/hr (heavy work), and 0.98 m^3/hr (light work).

8. Quantitative and Qualitative Risk Assessments

a. Oncogenic Effects

i. Introduction

In PD-1 the Agency concluded that a rebuttable presumption against registration (RPAR) had arisen against inorganic arsenical pesticides based on oncogenicity. Further, the Agency concluded in the Analysis of Rebuttals to PD-1 (Part II.C.2.c) that the presumption of oncogenicity was not successfully rebutted.

ii. Quantitative Risk Estimates

Arsenic cancer risk estimates for inhalation and dermal exposure* are based on several independent epidemiological studies.

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* These exposures were converted to average lifetime exposures.

The risk model for inhalation exposure is explained in the "Preliminary Report on Population Risk to Arsenic Exposures" (CAG, 1978a). This model is based data from three epidemiological studies, two in copper smelter workers and one in a pesticide manufacturering plant (see II.C.2.c). It is:

$$R = 1 - \exp(-X \times 2.953 \times 10^{-3})$$

where R is the lifetime cancer risk due to a lifetime of continuous exposure to air containing X ug/m^3 of arsenic.

Risk estimates for dermal and oral exposure* (gastrointestinal absorption) are from a model explained in another Cancer Assessment Group report (CAG, 1978b). The model is based upon data from an epidemiologic study of skin cancer in an area of Taiwan which had arsenic contamination of drinking water (see II.C.2.a).

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* The exposures given in mg/kg were converted to ug/m^3 by assuming a body weight of 60 kg and a breathing rate of 1.47 m^3/hours (36 m^3/day).

The model is:

$$\text{Risk} = \frac{2.41423 \times C}{2.41423 \times C + 6.02793}$$

where the quantity C is the concentration of arsenic (mg/liter) in drinking water[*].

In the case of the flooded basement, it is assumed here that the exposure from cleaning out a flooded basement occurs only once in a person's lifetime (70 years). Therefore, in this case the average lifetime exposure is only:

$$\frac{1}{365 \text{ days/yr} \times 70} = \times 10^{-5} \text{ of the daily exposure.}$$

The lifetime cancer risks due to exposure to inorganic arsenicals are shown in Table II.C-6

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[*] The exposure in mg/kg/day were converted to mg/liter by assuming a 60 kg body weight and a water consumption of 2 liters/day.

TABLE II.C-6

LIFETIME PROBABILITY OF CANCER (DERMAL, INHALATION, AND GASTRO-INTESTINAL) DUE TO INORGANIC ARSENIC EXPOSURE

Use description	Dermal	Inhalation	G.I.	Total
I. Large scale industrial use				
a. background	---	1.9×10^{-2}	---	1.9×10^{-2}
b. bag emptying (dust)	6.0×10^{-3}	2.8×10^{-2}	---	3.4×10^{-2}
c. mixer concentrate	9.8×10^{-2}	1.9×10^{-2}	---	1.17×10^{-1}
dilute solution	7.0×10^{-3}	1.9×10^{-2}	---	2.6×10^{-2}
d. handler	7.6×10^{-3}	1.9×10^{-2}	---	2.6×10^{-2}
II. Brush-on application non-pressure	1.2×10^{-2}	---	---	1.2×10^{-2}
III. Handling, sawing, fabrication	7.9×10^{-3} to 3.9×10^{-2}	1.4×10^{-2}	1.1×10^{-1}	1.3×10^{-1} to 1.6×10^{-1}
IV. Resident in As treated homes	4.5×10^{-6}	4.0×10^{-6}	---	9.0×10^{-6}
V. Flooded basement (water)	4.0×10^{-7}	---	---	4.0×10^{-7}

b. Mutagenic Effects

1. Introduction

From the analysis of data presented in Table II.C-1, the Agency (EPA) concluded that both trivalent (arsenite) and pentavalent (arsenate) forms of inorganic arsenic can act as mutagenic agents. Further as dicussed in Part II.C.3 of this document, the Agency concluded that the presumption of mutagenicity for inorganic arsenicals was not successfully

As described in detail in PD-1, there is strong evidence supporting the mutagenicity of inorganic arsenic. Arsenic is mutagenic in several test systems, and in several biological phyla. Sodium arsenite and sodium arsenate have been shown to be mutagenic in both *in vitro* and *in vivo* tests, including the following types of tests; Gene (point) mutations occur when sodium arsenite is tested with bacterial *(Escherichia Coli)* (Nishioka, 1975) or mammalian (hamster cells) *in vitro* (Casto,1977a). Chromosomal aberrations are caused by sodium arsenite and sodium arsenate as seen in *in vitro* tests with human cells (Oppenheim and Fishbein, 1965; Paton and Allison, 1972) and in *in vivo* tests with mice (Sram and Bencko, 1974) and humans (Petres *et al.*, 1970, 1977).

Potassium arsenite caused DNA damage in human lymphocytes *in vitro* (Burgdorf *et al.*, 1977). DNA repair *in vitro* was decreased by sodium arsenite and sodium arsenate in ultraviolet light exposed bacteria (*E.Coli*) (Rossman *et al.*, 1975, 1977) *Bacillus subtilis*) (Nishioka, 1975) and by sodium arsenate in xenon lamp-exposed human epidermal cells (Jung *et al.*, 1969; Jung and Trachsel, 1970). In addition, these inorganic arsenical compounds affected DNA synthesis, and mitosis, by their metabolic and cellular toxicity effects as seen in *in vitro* and *in vivo* tests in mammalian systems (see eight references in PD-1).

ii. Qualitative Risk Assessment

The mechanisms whereby the inorganic arsenicals cause mutations may include the following: 1) direct incorporation of arsenic into the RNA and DNA molecule in place of phosphorous; 2) indirectly by competitive inhibition of phosphorous insertion into polynucleotide chains; and 3) indirectly through inhibition of enzymes (arsenic reacting with SH (sulfhydryl) groups of polypeptides) involved in DNA and RNA synthesis, regulation, and repair of damaged DNA.

Table II.C-7 lists summaries of reports discussed in PD-1 and additional studies reviewed by the Agency since the publication of the PD-1. These studies form the basis of the inorganic arsenical compound's mutagenic risk assessment.

TABLE II.C-7

SUMMARY OF SIGNIFICANT STUDIES FOR INORGANIC ARSENICALS

MUTAGENIC RISK ASSESSMENT

Chromosomal Aberrations

Authors	Petres et al., 1970[b]	Petres et al., 1977[b]
System	Human lymphocyte cultures from chronic arsenic exposed patients	1. Human lymphocyte cultures from chronic arsenic exposed patients 2. Arsenic, 0.0-100 ug treated human lymphocyte cultures from normal persons.
Agent	Arsenic (unspecified)	Arsenate
Results	Aneuploidy, chromatid breaks, a centric fragments at greater frequency than untreated control. control. Normal arsenic treated cells had Dose-Response effect at 0.0 ug-100ug.	Same as Petres et al., 1970
Comments	Experimental group (long-term exposure) were vintners and other patients with psoriasis, also some excision of arsenic induced carcinomas. Similar effects were found in normals lymphocytes after treatment with arsenic.	Same as Petres et al., 1970

Sister chromatid Exchange (SCE)

Authors	Burgdorf et al., 1977[b]
System	Human lymphocyte cultures from patients
Agent	Potassium Arsenite
Results	Higher level of SCE in experimentals than control
Comments	The experimental group consisted of six patients treated with Fowler's solution for 4 to 27 years, for either asthma, psoriasis or anxiety. All had skin cancer.

TABLE II.C-7 Continued

Chromosomal Aberrations

Authors	Beckman et al., 1977 Nordensom et al., 1978 Beckman et al., 1979
System	Human lymphocyte cultures from workers exposed to arsenic (and other unidentified toxic agents)
Agent	Arsenic (unspecified)
Results	Chromosome gaps, dislocated chromatids, dicentric chromosomes, rings, acentric fragments and other abnormalities.
Comments	All aberrations in chronic (high, medium and low) exposure groups and newly exposed workers higher than controls ($p<0.001$) Smoking, exposure to lead and/or selenium were considered in analysis.

Chromosomal Aberrations

Author	Paton and Allison, 1972	
System	Normal human leucocyte cultures, human diploid fibroblasts	Normal human leucocyte cultures
Agent	Sodium Arsenite	Sodium Arsenate
Results	Chromatid breadage; arsenite effect>arsenate effect. Chromosome exchanges and chromosome damage noted.	
Comments	Arsenite 9.7 times greater effect than arsenate in percent than arsenate in percent of chromatids with breaks in cultured leucocytes and 4.8 times higher than control (untreated leucocytes).	

Chromosomal Aberrations

Authors	Oppenheim and Fishbein, 1965
System	Normal human leucocyte cultures
Agent	Potassium Arsenite
Results	Chromosome gaps, breaks, translocations, rings. Cell division was suppressed and there was an increased number of broken metaphase plates, at 1 uM concentration arsenite.
Comments	10 uM arsenite induced 70% damaged cells over control value. This was higher than urea hydroxyurea or othr chemicals tested at even vastly higher concentrastions.

TABLE II.C-7 Continued

Dominant Lethal

Authors	Sram and Bencko, 1974
System	ICR-SP mice 4 generation study *in vivo*
Agent	Sodium arsenite chronic 1.6 mg/kg/day, 9-10 mg/kg/day orally, 8 weeks Sodium arsenite 1 acute dose, 250 mg/kg
Results	At the acute dose and the high chronic dose, no effects noted. At the low dose, overall dominant lethality and and pre-implantation lethality occurred. At 9-10 mg/kg/day, similar results occurred when TEPA was injected.
Comments	Positive dominant lethal effects at the low dose. Possible co-mutagen role for TEPA to induce dominant lethal effects after chronic exposure to arsenite.

Chromosomal Abberations

Authors	Sram, 1976
System	ICR random bred mice, Bone marrow cells
Agent	Sodium Arsenite 1.6 mg/kg/day or 9-10 mg/kg/day orally 8 weeks
Results	At 1.6 mg/kg/day, 7.6% above normal values, abnormal chromosomes. At 9-10 mg/kg/day 3.2% above normal values. Abnormal chromosomes at 9-10 mg/kg/day plus control mutagen TEPA, 56.4% over normal value. TEPA (control mutagen) gave 34% abnormal chromosomes over normal value.
Comments	Possible co-mutagen role for TEPA to enhance chromosome aberrations after chronic exposure to arsenite.

Organ and Tissue Histopathology

Authors	Bencko et al., 1968
System	Hairless mice
Agent	Arsenic trioxide 0.75% mg/kg/day or 7.5 mg/kg/day for 256 days
Results	At 0.75 mg/kg/day skin, liver, kidneys and spleen had arsenic attributable pathology. Testes did not. At 7.5 mg/kg/day all above tissues had increased pathology and testes germinative epithelium appeared to be heavily deteriorated.
Comments	Mouse testicular germnative epithelium is targeted by 7.5 mg/kg/day administered for 256 days. The mouse strain employed, however, is not a normal representative of the specie.

TABLE II.C-7 Continued

(a) Other chromosome aberration studies not listed here are found in PD 1 and discussed elsewhere in this document.

(b) Study listed in PD 1

(c) TEPA = tris (1 aziridinyl) phosphine oxide

One study indicated that trivalent arsenic produces a heritable mutagenic effect in mice (Sram and Bencko, 1974). The dominant lethal study (Sram and Bencko, 1974) showed that sodium arsenite orally administered to mice at 1.6 mg/kg/day over four generations resulted in overall dominant and preimplanation lethality. However, a dose level of 9-10 mg/kg/day did not produce dominant lethality or changes in male fertility. Since a positive response was observed at the low dose, and a negative response occurred at the high dose, this study can only be suggestive of a positive result. However, in related experiments, a known mutagen, TEPA (tris (1-aziridenyl) phosphine oxide) was administered intrapenitoneally as a single dose of 1.0 mg/kg to three groups of males from the F3 generation. The three groups included untreated males, 1.6 mg/kg/day arsenite-treated, and 9-10 mg/kg/day arsenite-treated males. The results were as follows: TEPA alone gave a higher level of dominant lethals and related effects than either arsenite treatment. TEPA plus arsenite at 1.6 mg/kg/day produced no significantly different effects from arsenite alone. But TEPA administered to F3 males after chronic exposure to 9-10 mg/kg/day arsenite gave a distinctly additive effect. This unusual result indicated that some change must have occurred at the higher arsenite dosage, which did not produce observable effects until TEPA administration. One may speculate that TEPA acted as a "comutagen" in this experiment.

A parallel effect may be seen in the chromosome aberration studies of bone marrow cells (Sram, 1976), (see Table II.C.7).

The protocol used was similar to the dominant lethal study, except that bone marrow of treated and control mice were examined for various kinds of chromosomal aberrations following chronic arsenite exposure of the animals. A further parallel effect to that seen in the dominant lethal study was the observed percent of abnormal cells from arsenite-treated mice. These parallel effects were especially noteworthy when the figures for cytogenic analysis and dominant lethals were compared. Again, an additive affect of TEPA is seen at the higher arsenite treatment level for bone marrow cells. The dominant lethal study in particular provides strong evidence in support of a heritable mutagenic risk of arsenic for rodent species, and may permit extrapolation to humans. This is further supported by the evidence described in the following studies.

In an experiment with hairless mice*, groups of animals were exposed to arsenic trioxide in drinking water for 256 days at dosages of 0.75 mg/kg/day and 7.5 mg/kg/day respectively (Bencko, 1977, Bencko _et al_., 1968). Mouse tissues, including skin, liver, kidneys, spleen and testes were examined for pathological changes attributable to arsenic at the termination of the experiment. Such pathological changes were found in all tissues except testes in the low dosage group. In the high dosage group, more pronounced pathological changes were observed in the same group of tissues. In addition, heavy deterioration was found in the germinative epithelium of the testes in the high dosage group. This experimental data together with the dominant lethal study of Sram and Bencko (1974) provides evidence that arsenic is a potential human mutagen.

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* The hairless mouse however is deficient in immune T cell (thymocyte) function and its thymus deteriorates early in life.In addition, the animal has deficienceis in humoral immune function and abnormalities are also be found in the spleen (FASEB, 1979).

In another study using white Swiss mice, an arsenic dose of 0.075 mg/kg/day was administered for three weeks to white Swiss mice in the drinking water. The authors found that the antibody producing cells (secondary immune response) was depressed to 55% of the control value (Blakeley et al., 1980). Therefore, immunological effects cannot be excluded from having an impact on other pathological symptoms resulting from arsenic treatment.

The mutagenic potency of the inorganic arsenical compounds is shown on Table II.C.8. The relative mutagenic potencies of trivalent ad pentavalent arsenic in acute and chronic exposures of cell cultures were studied by Paton and Allison (1972), see Table II.C-8. Exposing human leucocyte cells in culture, to sodium arsenite (trivalent) at 5.8×10^{-9} M for the same time period for a 48 hour acute resulted in 48% chromosomal aberrations as compared with sodium arsenate (pentavalent) at 5.7×10^{-9}M which gave 5% chromosomal aberrations. Untreated

TABLE II.C-8

Comparison Of Arsenite And Arsenate On Acute Exposure Of Cultered Human Cells[a]

Human Cell Line	Agent	Concentration	Exposure Time	% Cells with Chromosome Aberrations
Wl 38	Na arsenite	5.8×10^{-9} M	24 hours	29%
WRC 5	Na arsenite	5.8×10^{-8} M	24 hours	40%
Leucocytes	Na arsenite	5.8×10^{-9} M	48 hours	48%
Leucocytes	Na arsenite	5.7×10^{-9} M	48 hours	5%
W138 (control)	-	-	24 hours	3%
MRC 5 (Control)	-	-	24 hours	2%
Leucocytes (control)	-	-	48 hours	1%

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[a] abstracted from Table III, Patton and Allison, 1972

human leucocytes gave 1% aberrations as a control value. Both arsenate and arsenite values for chromosome aberrations were statistically different than the controls.

Human exposure to arsenic has also resulted in chromosomal aberrations. The Study by Petres et al., (1970, 1977) showed that long-term expposure of vineyard workers (vintners) or patients (treated for psoriasis) to inorganic arsenicals resulted in high levels of chromosomal aberrations in their lymphocytes when compared with lymphocyte chromosomes from non-exposed persons. This was demonstrated by collecting blood from arsenic exposed and non-exposed individuals, separating the lymphocytes, inducing them to replicate using standard culture techniques and examining the chromosomes for the various abnormalities (aberrations) see listing Table II.C-7 (Petres et al., 1970, 1977). Unfortunately, neither of the two papers reported the dose levels of arsenic to which the patients had been exposed.

The work of Burgdorf et al., (1977) employing the lymphocyte culture technique on patients treated with Fowler's solution (a potassium arsenite compound) demonstrated that all six patients showed a high level of sister chromatid exchange (SCE). The patient group had a mean level of 14 SCE per mitosis, in which 44 normal controls had a mean level of 5.8 SCE per mitosis (Fisher exact test used; P, < 0.01). Chromosome breakage analysis of lymphocyte chromosomes showed no differences between the patient group and the normal controls. The patient group all had stigmata of arsenic chronic exposure as well as biopsy proven skin cancers. Arsenic treatment periods of the patients ranged from four months to 27 years. The authors (Burgdorf et al., 1977) concluded that the significantly elevated SCE in cultured lymphocytes from arsenic-treated patients may be related to arsenical carcinogenesis.

Thus, these papers present evidence that human exposure to arsenic can lead to an increased incidence of chromosomal structural abnormalities and abnormalities in chromosome number (aneuploidy) in man.

In addition, epidemiological evidence shows that workers at a smelter where arsenic is produced showed significantly higher chromosomal abnormalities then control populations.

In another series of experiments with human lymphocytes in culture (Beckman et al., 1977, Nordenson et al., 1978, Beckman et al., 1979) groups of workers employed at the Ronnskar smelter in northern Sweden were tested for exposure to arsenic (see Table II.C-7). Portions of these studies are discussed in the teratology and fetotoxicity section of this document. Workers at the smelter were exposed to a number of toxic substances, including arsenic, lead and selenium. Smoking and exposure to lead and selenium were considered in the analysis of the data. Normal controls were a group of healthy males from Umea, about 100 kilometers from the Ronnskar smelter.

For the experiment, workers were divided into high, medium and low exposure groups by age and years employed at the smelter (i.e., high exposure: 54 years age, 22 years exposure; medium exposure: 32.9 years age, 6.5 years exposure; low exposure: 32 years age, 4 years exposure), and new employees (32.5 years age, less than 4 years exposure). The "new employees" group were noted as living close to the smelter before their employment. The number of chromosomal aberrations in lymphocytes of all workers together was statistically significantly higher than that of the controls ($P < 0.01$). Three types of aberrations were found significantly increased over the controls ($P < 0.001$): gaps, chromatid aberrations and chromosomal aberrations. Newly employed workers did not have a significantly higher frequency of aberrations than the low exposure group. The frequencies of aberrations in the high versus medium group ($P < 0.05$) and the medium versus the low group ($P < 0.01$) showed statistically significant differences and appeared to demonstrate a dose-response relationship.

Urinary arsenic levels however did not correlate with arsenic exposure. Medium exposure workers had the highest urinary arsenic levels (urinary arsenic levels for new workers or controls were not reported). The study conclusions focussed on the analysis of the kinds of chromosome aberrations found in the arsenic expposed groups versus the control group. Chromosome gaps were predominant in the control group, whereas exposed workers had abundant chromosome breaks. In exposed workers, the number of gaps correlated with the number of breaks. The authors commented that the frequencies of aberrations may show large variations (from 0-25 per 100 cells) even for similar exposures, suggesting a speculation as to the role of genetic disposition in response to genotoxic agents like arsenic. The overall results of these experiments support the work of Petres *et al*. (1970, 1977).

iii. Summary

The inorganic arsenical compounds have the intrinsic potential via several possible mechanisms (gene mutation, chromosome aberration, DNA damage, and effects on DNA repair) to mutate mammalian cells. Evidence (Petres *et al*., 1970, 1977, Burgdorf *et al*., 1977) shows that human exposure to arsenic can result in chromosome aberrations and aneuploidy *in vivo* . Epidemiological evidence shows that workers at a smelter where arsenic was produced showed significantly higher chromosomal abnormalities than control populations (Beckman *et al*., 1977, 1979; Nordenson *et al*., 1978). The evidence strongly suggests that arsenic was the sole cause of the chromosomal abnormalities. One study (Sram and Bencko, 1974) suggests that arsenic caused heritable genetic defects in mice. Bencko *et al.* (1968) showed that chronic exposure to arsenic trioxide caused deterioration of the germinative epithelium of the testes in hairless mice, thus arsenic affected the reproductive tissues. Thus, there is ample evidence that occupational exposure (although unquantified) to arsenic has the potential to produce heritable mutagenic effects in humans, and that these effects may indeed be high.

c. Teratology and Fetotoxicity Effects

i. Introduction

In PD-1 the Agency concluded that a rebuttable presumption against registration (RPAR) had arisen against inorganic arsenical pesticides based on teratogenicity and fetotoxicity.

Further, in Section II.C.4 of this document the Agency determined that the presumption of teratogenic and fetotoxic risk was not successfully rebutted. The studies of Hood _et al_. (1977, 1978) demonstrated evidence of arsenical teratogenicity. The study of Matsumoto _et al_. (1974) demonstrated evidence of fetotoxicity. The Agency assessed the study by Hood (1979, unpublished) submitted by AWPI as Appendix #4, Vol. III as being inadequate for a quantitative risk analysis.

ii. Special Considerations

Acute and Chronic Toxicity of Arsenic to Animals and Humans

The animal studies listed in PD-1 demonstrate the potential teratogenicity and fetotoxicity of the inorganic arsenicals. Estimation of the actual human hazard from fetotoxicity and teratogenicity studies using animals requires consideration of several factors. Thus, predictive uncertainty always results from differences in metabolic activation or detoxification between the human and the test animal. Tissue distribution of the pesticide is another consideration. The Agency is aware, for example, that the capacity of the rat to sequester arsenic in hemoglobin significantly exceeds that of man and some other test animals (Ducoff et al., 1948). Such an unusual tissue distribution of pollutant in a test animal might introduce additional uncertainity into the extrapolation of toxicity data for human risk analysis. It appears, in fact, that with several acute or chronic toxicity parameters for inorganic arsenic, a risk extrapolation requires qualification, since the human sensitivity has been shown in many cases to be greater than that demonstrated in test animals.

To illustrate this comparison of animal and human sensitivities to the affects of arsenic, Tables II.C-10 through 13 provide, for both laboratory animals and humans, listings of acute and chronic toxicity data for inorganic arsenic. After reviewing the toxicity of arsenic (inorganic) in drinking water, Sagner (1973) observed that most cases of human poisoning occurred at lower levels than those observative rats. Human poisoning occurred when concentrations reached 0.5 to 1.0 mg/liter, which provides a doseage of about 0.017 to 0.034 mg/kg/day.

Other Effects

Although the mechanism of action is not known for any teratogenic chemical, several observations can be mentioned that deal with arsenical effects on biological systems.

Fowler *et al*. (1977) studied structure and function of liver mitochondria and hepatocytes in male rats given drinking water containing 20, 40 or 85 ppm arsenic as arsenate for 6 weeks. Significant depression of growth rate occurred only at the 85 ppm (8.5 mg/kg/day) dose level. Mitochondria in hepatocytes from animals at the upper two dose levels showed extensive swelling. Mitochondrial respiratory function (for specified substrate conditions) exhibited a dose-related depression at 20 ppm (approx. 2.0 mg/kg/day) and 40 ppm arsenate. Uncoupling of oxidative phosphorylation (depressed P/O ratios) appeared to be less "substrate restricted" in mitochondria only from animals of the 85 ppm dose group.

For sodium arsenite a dose of 125 ppm (about 13 mg/kg/day) caused bile duct enlargement when mixed in the feed of rats (National Research Council, 1976). In the mouse, 5 ppm sodium arsenite (about 0.75 mg/kg/day), when administered in drinking water, caused shortened life span and alteration of sex. Sodium arsenite, however, is reported to be markedly more toxic in the pig when administered through drinking water rather than in the feed.

iii. Summary of Studies used in the Risk Assessment

Table II.C-9 presents those studies of either arsenate or arsenite showing teratogenicity/fetoxicity after dosing by a route (oral ingestion or gavage) relevant to human production of (or exposure to) arsenic-treated wood.

Hood et al. (1978) reported significant teratogenic effects at 120 mg arsenate/kg oral dose, but gave no maternal toxicity data. The Agency notes that the teratogenic level listed in Table II.C.II (120 mg/kg) is in the LD_{50} range for mice. The only data reviewed by the Agency on maternal toxicity was reported in the Hood et al. (1977) study, and maternal toxicity was estimated at 16% for an oral dose of 120 mg arsenate/kg. Matsumoto (1974), who used arsenite rather than arsenate, reported that 10 mg/kg produced significant fetotoxic effects in mice. He did not observe maternal toxicity. The Agency has determined that with the available data the level of maternal toxicity observed at arsenic dosages sufficient to cause teratogenicity, and/or fetotoxiicity effects cannot be estimated.

The effects of arsenic on teratogenicity and fetotoxicity can be summarized as follows: No teratogenic or fetotoxic effects were seen in the rat at 4.4 (arsenite) and 6.5 (arsenate) mg/kg/day doses, (Kimmel and Fowler, 1974). Fetotoxicity was observed in mice at 10, 20 and 40 mg/kg/day (arsenite), but no fetal malformations were observed at these levels (Matsumoto, 1974).

TABLE II.C-9

Summary Of Arsenic Studies Dealing With Teratogenicity And Fetotoxicity Using Routes Of Exposure Relevant To Human Risk Assessment

Author	Species	Chemical	Dose/Route	Results	Conclusions
Hood, et al., (1978)	CD-1 Mouse	Na Arsenate	120 mg/kg single Oral dose days 7-15	Decreased birth weights with greatest difference day 11. In utero deaths with largest numbers day 11 (64% over controls) skeletal malformations days 7-15 with highest values day 9.	Observed significant teratogenic and fetotoxic effects 120 mg/kg is teratogenic and fetotoxic.
Hood, et al., (1977)	CD-1 Mouse	Na Arsenate	120 mg/kg PO single oral dose days 9 and 10	In utero deaths 5% over controls 1% gross malformations, 2/9 maternal deaths, day 9. In utero deaths 14% over controls. 3% gross malformations, maternal deaths 2/16.	Same as above, except that gross malformation were not significant.
Kojima (1974)	Wistar Rat	As trioxide	0.5, 2.5, 5.0 mg/kg/day diet during gestation.	None Reported	NOEL = 0.5, 2.5, 5.0 mg/kg/day for repro. effect (# of litters)
Kimmel and Fowler, (1977b)	Rat	Na Arsenate Na Arsenite	30 ppm and 90 ppm drinking water during gestation. mg/kg/day = 2.7 and 6.5 (arsenate), and 1.9 and 4.4 (arsenite)	None Reported	NOEL = 4.4 (arsenite) and 6.5 (arsenate) mg/kg/day for teratogenic & fetotoxic effects.

TABLE II.C-9 Continued

Summary Of Arsenic Studies Dealing With Teratogenicity And Fetotoxicity Using Routes Of Exposure Relevant To Human Rist Assessment

Author	Species	Chemical	Dose/Route	Results	Conclusions
James, (1966)	Ewe	K Arsenate	50 mg/kg/day capsule	None reported. One ewe delivered a small lamb	
Morris, et al., (1938)	Osborne-Mendel Rat	As trioxide	3.9 or 30.9 mg/kg/day thru 2-generations	None Reported	
Matsumoto, et al (1974)	ICR Mouse	Na Arsenite	10, 20, or 40 mg/kg/day orally days 9-11 of gestation		No significant teratology effects observed. However; observed significant fetotoxic effects at all levels, including lowest dose = 10 mg.

TABLE II.C.10

Acute Toxicities of Inorganic Arsenicals to Various Mammalian Species

Chemical	Species	Route	Effect/Dose	References
Arsenic Acid	Human	Oral	LDLo: 5 mg/kg	d
	Rat	Oral	LD50: 48 mg/kg	a
Arsenic Pentoxide	Human	Oral	LDLo: 5 mg/kg	d
	Rat	Oral	LD50: 8 mg/kg	a
	Mouse	Oral	LD50: 55 mg/kg	a
Arsenic Trioxide	Man	Oral	TDLo: 16 mg/kg	a
	Man	Inhalation	TCLo: 700 ug/m^3	a
	Rat	Oral	LD50: 20 mg/kg	a
	Rabbit	Oral	LDLo: 4 mg/kg	a
	Mouse	Oral	LD50: 45/mg/kg	a
	Swiss Mouse	Oral	LD50: 39.4 mg/kg	c
Sodium Arsenate	Human	Oral	LDLo: 5 mg/kg	d
	Rabbit	Oral	LDLo: 12500 ug/kg	a
Calcium Arsenate	Human	Oral	LDLo: 5 mg/kg	d
	Rat	Oral	LD50: 20 mg/kg	a
	Rat	Dermal	LD50: 2400 mg/kg	a
	Dog	Oral	LD50: 38 mg/kg	a
	Rabbit	Oral	LDLo: 50 mg/kg	a
	Mammal (unspecified)	Oral	LD50: 35 mg/kg	a

TABLE II.C.10 Continued

Sodium Arsenite	Human	Oral	LDLo: 5 mg/kg	d
	Rabbit	Oral	LD50: 41 mg/kg	a
	Rabbit	Dermal	LD50: 150 mg/kg	a
	Rabbit	Oral	LDLo: 7500 ug/kg	a
	Mammal (unspecified)	Oral	LD50: 10 mg/kg	a
	Deer (yearling Doe)	Oral	LDLo: 923 mg	b
Copper Acetoarsenite	Human	Oral	LDLo: 5 mg/kg	d
	Rat	Oral	LD50: 22 mg/kg	a
	Mammal (unspecified)	unknown	LD50: 18 mg/kg	a
	Wild Rabbit	Oral	LDLo: 10.5 mg/kg	b
	Hare	Oral	LDLo: 10.5 mg/kg	b

TABLE II.C.11

Summary of Acute Toxicity Data

Comparison of Acute Toxicity of Inorganic Arsenic in Humans, Rats and Mice

	Human	Rat	Mouse
Arsenic Acid (+5)	LDLo: 5 mg/kg*	LD50 48 mg/kg	-
Arsenic Pentoxide (+5)	LDLo: 5 mg/kg	LD50 8 mg/kg	LD50: 55 mg/kg
Arsenic Trioxide (+3)	LDLo: 16 mg/kg TCLo: 700 ug/m^3	LD50 20 mg/kg	LD50: 45 mg/kg LD50: 39.4 mg/kg
Sodium Arsenate (+5)	LDLo: 5 mg/kg	-	-
Calcium Arsenate (+5)	LDLo: 5 mg/kg	LD50 20 mg/kg	
Sodium Arsenite (+3)	LDLo: 5 mg/kg	-	-
Copper Acetoarsenite (+3)	LDLo: 5 mg/kg	LD50 22 mg/kg	-

* A human LDLo value of 1.4 with a range of 0.76 - 1.95 mg As/kg is reported (Vallee, B. L., D. D. Ulmer and W.E.C. Wacker, Arsenic Toxicology and Biochemistry. A.M.A. Arch. Ind. Health. 21:132-151.

TABLE II.C-12

Chronic Effects and No-Effect Levels in Animals from Exposure to Inorganic Arsenic

Effect Level (mg/kg/day)	NOEL (mg/kg/day)	Animal Species	Chemical	Symptoms	References
	30.9	Rat	Arsenic trioxide	No effects thru two generations	Morris et al. 1938
13		Rat	Sodium arsenite in feed	Bile duct enlargement	NRC, 104
	6	Rat	Sodium arsenate in feed	No-effect dose for growth rate	NRC, 104
2		Rat	Sodium arsenate in	Depressed mitochondrial respiration after 6 weeks	Fowler & Wood, 1979
7.5		Mouse	Inorganic arsenic in drinking water	Damage to germinal epithelium of testes	Bencko, 1977
0.75		Mouse	Arsenite in drinking water	Shortened life span; alteration of sex	NRC, 634 NRC, 636
	0.7	Mouse	Arsenite in drinking water	Decreased average litter size; increased male/female ratio	Schroeder & Mitchener, 1971
1.5		Cat	Arsenate or arsenite	EKG abnormalities	Massmann & Opitz, 1954

TABLE II.C-13

Chronic-Effect Levels in Humans from Exposure to Inorganic Arsenic

Effect Level (mg/kg/day)	Chemical Species	Symptons	Reference
1.0 (infants)	Inorganic arsenic in dried milk	After 20 days produced 1% deaths and impairments of learning (Morinaga)	Fowler, 1979
0.05	Calcium arsenate in soy sauce	After 2-3 weeks produced hyperpigmentation, anorexia, edema, peripheral neuropathy, EKG abnormalties.	Mizuta et al., 1956
0.04	Calcium arsenate in drinking water	Hyperpigmentation, melanosis, hyperkeratosis.	Nagy et al., 1975
0.03-0.09	Inorganic arsenic in well water	Melanosis, keratosis, anemia, liver swelling, EKG abnormalities (Niigata)	Fowler, 1977
0.03	Inorganic arsenic in drinking water	Skim manifestations and some deaths. (Antofagasta)	Borgono and Graiber, 1972
0.005 (66.0-78.0 ppb)	Arsenite in wine	Hyperkeratosis, tendon reflexes absent, peripheral neuropathy. Three weeks continuous dosage after life-time consumption of large quantities of wine.	Houser and Vitek, 1979

Thus, the rat study shows 4.4 (arsenite) and 6.5 (arsenate) mg/kg/day to be non-teratogenic and non-fetotoxic, and the mouse study demonstrates that up to 40 mg/kg/day is non-teratogenic; however, the mouse study also shows that 10 mg/kg/day, the lowest dose tested, is fetotoxic. The study by Kojima (1974) shows that levels up to 5 mg/kg/day (arsenite) have no effect on the number of litters in rats (note, however, that teratogenic effects were not assessed). The Agency will, therefore, use 5 mg/kg/day arsenite or arsenite as a provisional estimate of a no-effect level (NOEL) for teratogenicity and fetotoxicity. The Agency realizes that in the mouse a no-effect level for fetotoxicity has not been established. This is a serious data gap. The dose of 5 mg/kg/day for the rat is used for estimation only and cannot be construed as a no-effect level in mice.

iv. Quantitative Risk Estimates

Margins of Safety have been calculated for the various exposure sites where the use of inorganic arsenical wood preservatives is anticipated, (see Table II.C-14).

The Total Body Doses (TBD) were estimated from the dermal and inhalation exposure estimates (Day, 1980, Exposure Analysis for Inorganic Arsenic) as presented originally in PD-1 and amended after rebuttal comments (see Table II.C-5 in Part II of this document).

For the exposure and TBD calculations of the sawing and fabrication scenarios, the gastrointestinal absorption factor is added because it is anticipated that a significant portion of the inhaled dust particles will be trapped and ultimately swallowed.

Risk to teratogenic/fetotoxic effects was calculated using 5 mg/kg/day as the provisional no-effect level.

v. Summary

As shown in Tables II.C-10 through 13, humans appear to be more sensitive to arsenic toxicity than are mice and rats. Therefore a prudent scientist might expect the teratogenic/fetotoxic margins of safety to be lower for humans than for rats and mice. If humans are more sensitive to arsenic toxicity than are rodents, and it appears that they are, the margins of safety could be much lower than those shown in Table II.C-14. As discussed in this section there is also epidemiological evidence that humans exposed to arsenic in smelters experienced teratogenic/fetotoxic effects.

TABLE II.C-14

Inorganic Arsenic

Margins of Safety for Teratogenic/Fetotoxic Effects

Use	Total Body Dose mg/kg/day	Margin of Safety
I. Large Scale Industrial Use		
a. Background	0.010	500
b. Bag Dumping	0.017	294
c. Mixer Concentrate	0.037	135
Mixer Dilute	0.012	417
d. Handler	0.012	417
II. Brush-on application to wood Non-pressure	0.003	1667
III. Handling treated wood (e.g. sawing and (fabrication)	0.039 to 0.047	128 to 106
IV. Residents	0.00003	128,000
V. Clean-up of flooded basements	0.0026	1923

D. Pentachlorophenol

1. Analysis of Rebuttal Comments Concerning Fetotoxic and Teratogenic Effects

a. Basis of Presumption

i. Introduction

In the studies summarized here, fetotoxic and teratogenic effects were reported in rats exposed to purified and commercial grade penta. Teratogenic effects were reported in rats exposed to a mixture of two unspecified isomers of hexachlorodibenzo-p-dioxin (HxCDD). Specifically, exposure to penta contaminated with these HxCDD isomers resulted in statistically significant increases in the incidence of skeletal and soft tissue anomalies, growth-retarded fetuses, and embryonic resorptions in the litters of treated dams.

ii. Studies with Penta

Schwetz _et_ _al_. (1974) studied the effects of purified and commercial grade penta on rat embryonal and fetal development. Doses of 5, 15, 30, and 50 mg/kg/day of purified penta and 5.8, 15, 34.7, and 50 mg/kg/day of commercial penta were administered by gavage on gestation days 6 through 15 inclusive. (Note that 5.8 and 34.7 mg/kg/day of commercial penta are equivalent to 5 and 30 mg/kg/day of purified penta.) Both purified and

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commercial penta caused statistically significant increases in fetal resorptions at the two higher doses (Table II.D-1). It is interesting that at 30 and 50 mg/kg/day, purified penta had a more pronounced effect than the two highest doses of commercial penta. For example, at 50 mg/kg/day purified penta caused 100% incidence of fetal resorptions, while commercial penta caused 58% resorptions. At 30 (purified) and 50 (commercial) mg/kg/day, there were statistically significant differences in the sex ratio of surviving fetuses: in both cases males were heavily predominant. These investigators also found that administration of penta during early organogenesis (days 8 through 11 of gestation) had a more pronounced effect on fetal resorption than did its administration during late organogenesis (days 12 through 15).

In this study, the no-observable-effect level (NOEL) for fetal resorption was 5.8 mg/kg/day of commercial grade penta and 15 mg/kg/day of purified penta. Measurements were also taken on fetal body weight and crown-rump length, both of which decreased with increasing dose. The NOEL for these parameters was 15 mg/kg/day for both commercial grade and purified penta.

Schwetz _et_ _al_. (1974) also investigated the fetal anomalies in rats caused by penta. They studied the effects produced by oral adminstration (gavage) of 5.8, 15, 34.7, and 50 mg/kg/day of commercial grade penta, and 5, 15, and 30 mg/kg/day of purified penta. In one experiment, they administered these amounts of penta during days 6 through 15 of gestation; significant increases in skeletal defects of the ribs, sternebrae, and

TABLE II.D-1

Effect of Pentachlorophenol on the Incidence of Fetal Resorptions and on the Sex Ratio of Survivors[a]

Test Material and Dose (mg/kg/day)	Resorptions Among Fetuses		Resorptions Among Litters	
	%	No.	%	No.
Vehicle Control[b]	4.2	15/358	30.3	10/33
Pentachlorophenol[c]				
Commercial				
5.8	7.1	15/212	55.6	10/18
15	8.8	17/194[d]	64.7	11/17[d]
34.7	27.2	64/235[d]	94.7	18/19[d]
50	58.1	108/186[d]	93.3	14/15[d]
Purified				
5	4.2	8/189	46.7	7/15
15	5.9	13/221	38.9	7/18
30	97.5	233/239[d]	100.0	20/20[d]
50	100.0	229/229[d]	100.0	19/19[d]

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a. From Schwetz *et al.* (1974).
b. 2.0 ml/kg body weight corn oil per day.
c. Dosages were administered in corn oil (2.0 ml/kg).
d. Significantly different from control values by the binomial expansion test, $p<0.05$.

vertebrae were observed in the two highest dose groups of both purified and commercial penta. The lowest dose of purified penta (5 mg/kg/day) caused an increase in delayed skull ossification. In a second experiment, they gave 30.0 (purified) and 34.7 (commerical) mg/kg/day penta on days 8 through 11 of gestation to one group of animals, and on days 12 through 15 to a second group; significant increases in abnormal sternebrae and skulls were observed in animals treated with purified penta, and abnormal sternebrae in animals treated with commerical penta.

Larsen _et_ _al_. (1975) fed 60 mg/kg ^{14}C-penta to pregnant Charles River rats (CD strain) on day 15 of gestation. They detected negligible amounts (<0.3% of administered dose) of ^{14}C-penta in the placentae and fetuses up to 32 hours after dosing. This indicated that the amount of penta that passes through the placental barrier on day 15 is negligible. In a separate experiment reported in the same paper, a single oral dose of 60 mg/kg of unlabeled penta administered to separate groups of animals on days 8, 9, 10, 11, 12, or 13 of gestation had no significant effect on the rate of fetal resorptions in the test animals as compared with controls. However, significant reductions in fetal weight, another fetotoxic effect, were reported on days 9 and 10.

Hinkle (1973) reported on the absence of observed fetotoxic effects of penta in the Golden Syrian hamster. After doses of 1.25, 2.5, 5, 10, and 20 mg/kg were administered by gavage on days 6 through 10 of gestation, no differences were reported between control and test animals in these parameters: maternal body weight, fetal weight, litter size, and number of resorptions. There was some (unspecified) increase in maternal toxicity at the two highest doses. The author stated that penta was found in detectable amounts (unspecified) in the untreated animals as well as in their diet.

Fahrig (1978) observed decreases in litter size after intraperitoneal injection of pregnant mice at day 10 of gestation with 50 to 100 mg/kg penta. Control mice, on the average, produced more than 6 fetuses/dam, whereas litter sizes in the treated groups were about 4 fetuses/dam. Penta was administered in a 10% solution of dimethylformamide; a vehicle control was not reported. Litter size calculations included dams that had no litters.

It is clear from this discussion that the higher doses of penta can cause fetotoxic effects in experimental animals. Based on the results of Schwetz et al. (1974), the Agency, in PD-1, used 5.8 mg/kg/day of commercial penta as the NOEL for fetotoxicity.

iii. Studies with Dioxins

Commercial penta contains several forms of chlorinated dibenzo-p-dioxins (see Section I.A.3.a). Schwetz et al. (1973) administered purified HxCDD (two unspecified isomers) and octachlorodibenzo-p-dioxin (OCDD) by gavage to pregnant Sprague-Dawley rats on days 6 through 15 of gestation. Doses were 0.1, 1, 10, or 100 ug/kg/day HxCDD and 100 or 500 mg/kg/day OCDD.

In these experiments, there were significant increases over controls in fetal resorptions at the 10 and 100 ug/kg/day doses, as well as decreases in fetal body weight and fetal crown-rump length. Subcutaneous edema was observed at all doses except 0.1 ug/kg/day, which was considered the no-effect dose. At the two highest doses, dilated renal pelvis (at 10 and 100 ug/kg/day) and cleft palate (at 100 ug/kg/day) were also observed. In contrast, OCDD, at both dose levels (100 and 500 mg/kg/day), produced no fetal resorptions or other effects except for an increase in the incidence of subcutaneous edema at the high dose level.

Significant increases over the controls in all of the teratogenic parameters were observed at 100 ug/kg. For example, cleft palate was observed in 47% (8/17) of the fetuses exposed to HxCDD, compared with none (0/156) in the controls. Of the treated fetuses, 12% (2/17) had dilated renal pelvis compared with 0.6% (1/156) in the controls, and 31% (5/16) of the treated fetuses had abnormal vertebrae, compared with 6% (9/158) in the controls. In contrast, OCDD did not cause teratogenicity at 100 mg/kg/day; although 500 mg/kg/day caused subcutaneous edema, it produced no other observable effects. Because of the extremely high doses of OCDD required to produce an effect, the margins of safety for this dioxin isomer are much greater than those for HxCDD.

As the fetotoxicity NOEL (0.1 ug/kg/day) for HxCDD is lower than that for teratogenicity, the Agency will use the NOEL for fetotoxicity in the quanitative assessment of risk. (Note that errors on pages 43 and 46 of PD-1 mistakenly expressed this NOEL as 1.0 ug/kg/day.)

b. Analysis of Specific Rebuttal Comments

This analysis of rebuttals is based on the formal rebuttal comments and additional information received since the original publication of PD-1.

Rebuttal Comment 1: Blood Concentrations of Penta After Dosing (18)

Dow Chemical Company believes that the NOEL of 5.8 mg/kg/day used in PD-1 is too low. In support of this opinion, the rebutter provides calculations from a simulation model to show that the theoretical average daily blood concentration of penta after a single NOEL-dose of 60 mg/kg (Larsen et al., 1975), when averaged over 4 days, is very close to the theoretical average after 4 days of dosing at 15 mg/kg/day. The rebutter states that:

> Based on the similarity of these average blood concentrations during the 4 critical days of gestation, and the fact that 60 mg/kg administered singly is a no-effect-dose, the actual no-effect-dose for repeated administration

is probably closer to 15 mg/kg per day than to 5 mg/kg per day.

Agency Response: Although the hypothetical calculations submitted by the rebutter are interesting, the Agency is not convinced that the results calculated from a simulation model of a single dose (Larsen et al., 1975) can rebut the empirical results of experiments based on chronic administration. Schwetz et al. (1974) clearly showed that doses of commercial penta greater than 5.8 mg/kg/day are capable of producing fetotoxic effects in rats. In addition to other possibly relevant variables, the time-course of penta blood concentration (which is very different in the two experiments) may partially account for the difference in NOEL values.

Rebuttal Comment 2: Terminology of Fetotoxic and Teratogenic Effects (1, 18)

The American Wood Preservers Institute and Dow Chemical Company state that the sole reference (Schwetz et al., 1974) cited in PD-1 as evidence for the teratogenicity of penta in rats does not, in fact, support the conclusion of teratogenic effects from this chemical in either humans or rats. The rebutters claim that the distinctions between teratogenicity, embryotoxicity, embryolethality, and fetotoxicity are critical in the interpretation of the effects of penta. They state that 1) teratogenic effects are typically irreversible changes of a serious nature, 2) fetotoxic changes are typically reversible and are of lesser toxicological significance, and 3) embryolethality is a significant toxic end-point, but does not result in the birth of a malformed infant and is, therefore, not considered to be evidence of teratogenicity.

Agency Response: Generally, the term "teratogenic" is defined as the tendency to produce physical and/or functional defects in offspring *in utero*. The term "fetotoxic" has traditionally been used to describe a wide variety of embryonic and/or fetal divergences from the norm which cannot be classified as gross terata (birth defects), or which are of unknown or doubtful significance. Types of effects which fall under the very broad category of fetotoxic effects are death, reductions in fetal weight, enlarge renal pelvis edema, and increased incidence of supernumary ribs. It should be emphasized, however, that the phenomena of terata and fetal toxicity as currently defined are not separable into precise categories. Rather, the spectrum of adverse embryonic/fetal effects is continuous, and all deviations from the norm must be considered as examples of development toxicity. Gross morphological terata represent but one aspect of this spectrum, and while the significance of such structural changes is more readily evaluated, such effects are not necessarily more serious than certain effects which are ordinarly classified as fetotoxic (fetal death being the most obvious example).

In view of the spectrum of effects at issue, the Agency suggests that it might be useful to consider development toxicity in terms of three basic subcategories. The first subcategory would be embryo or fetal lethality. This is, of course, an irreversible effect and may occur with or without the occurrence of gross terata. The second subcategory would be teratogenesis and would encompass those changes (structural and/or functional) which are induced prenatally, and which are irreversible. Teratogenesis includes structural defects apparent in the fetus, functional deficits which may become apparent only after birth, and any other long-term effects (such as carcinogenicity) which are attributable to *in utero* exposure. The third category would be embryo or fetal toxicity as comprised of those effects which are potentially reversible. This subcategory would therefore include such effects as weight reductions, reduction in the degree of skeletal ossification, and delays in organ maturation.

Two major problems with a definitional scheme of this nature must be pointed out, however. The first is that the reversibility of any phenomenon is extremely difficult to prove. An organ such as the kidney, for example, may be delayed in development and then appear to "catch up." Unless a series of specific kidney function tests are performed on the neonate, however, no conclusion may be drawn concerning permanent organ function changes. This same uncertainty as to possible long-lasting aftereffects from developmental deviations is true for all examples of fetotoxicity. The second problem is that the reversible nature of an embryonic/fetal effect in one species might, under a given agent, react in another species in a more serious and irreversible manner. The Agency must therefore consider all such deviations from normal development in its risk assessment process, regardless of any appearance of reversibility.

The Agency agrees that the data of Schwetz et al. (1974) should be cited as evidence for fetotoxic effects, rather than for teratogenic effects. The Agency recognizes the value of making distinctions between teratogenicity, embryotoxicity, embryolethality, and fetotoxicity in order to scientifically categorize the effects of a toxic chemical. However, from a regulatory standpoint, a fetotoxic effect may represent as unacceptable a risk to the human fetus as would a teratogenic effect. The studies reported in PD-1 describe terata (malformations), fetal resorptions, and increased incidences of normal variants over controls. Any of these adverse effects may engender concern that a sufficient margin of safety may not exist between the test doses in animals and the exposure levels in humans.

In the case of technical penta, when the NOEL for the fetotoxicity of penta is considered in light of the exposure values, the margins of safety (MOS's) are lower than those obtained with the respective exposure figures and NOEL for the fetotoxicity of HxCDD. Consequently, the MOS's for the fetotoxicity of penta will be used in Part Vto develop the proposed regulatory decisions.

Rebuttal Comment 3: Distinctions between Teratogenicity and Embryotoxicity (1, 18)

The American Wood Preservers Institute and Dow Chemical Company state that the Agency is mistaken in using the study of Schwetz et al. (1973) to establish the teratogenicity of HxCDD because of the Agency's failure to distinguish between teratogenic effects and reversible, less severe anomalies. They claim these anomalies should be characterized only as embryotoxic effects. These rebutters state that the only finding in this study indicative of a teratogenic event was the induction of cleft palate. The rebutters point out that the other findings of dilated renal pelvis, subcutaneous edema, and abnormal vertebral development are evidence of embryotoxicity rather than teratogenicity.

Agency Response: The 1973 paper of Schwetz et al. states that, "By previously described definitions of teratogenicity and embryotoxicity, HxCDD is teratogenic in the rat at 100 ug/kg dose level...." At this dose on days 6 through 15 of gestation, cleft palate was produced in 47% (8/17) of the rat fetuses. The rebutters offer no evidence that any of the dose-related fetal anomalies described are reversible. This study adequately demonstrates that HxCDD is a potential cause of teratogenicity and other symptoms of developmental toxicity. Discussions of the categories of developmental toxicity (teratogenicity, embryotoxicity, fetotoxicity, etc.) do not diminish the Agency's concern about a chemical or its contaminants causing symptoms of developmental toxicity.

Rebuttal Comment 4: Relationship of Maternal Toxicity to Fetotoxicity (1, 18)

The American Wood Preservers Institute and Dow Chemical Company state that a 90-day toxicity study, a 2-year feeding study, and a 1-generation reproduction study each show a NOEL of 3 mg/kg/day. This correspondence of the NOEL values cited for fetotoxicity and maternal toxicity is presented as evidence for a low hazard of fetotoxicity from penta. The rebutters suggest that the observed fetal anomalies result indirectly from toxicity to the mother, and not from direct toxicity to the fetus. Thus, margins of safety which would protect the mother against other toxicological manifestations would also protect the developing embryo and fetus against adverse effects.

Agency Response: The rebutters have not demonstrated that maternal toxicity is the cause of the observed fetotoxicity. The concept that the fetotoxic effects of penta do not occur at doses lower than those causing maternal toxicity is refuted by the study of Schwetz *et al*. (1974). In this study there was a significant increase in percent of fetal resorptions at 15 mg/kg/day (commercial penta), a level which produced no maternal toxicity. Maternal toxicity did not appear until a dose of 34.7 mg/kg/day was achieved. In addition, it should be noted that the duration of exposure required to manifest fetotoxicity in an animal may be considerably less than the time to demonstrate a chronic or life-time effect. For this reason, a proper comparison of hazards involves consideration of the duration and timing of exposure in addition to the NOEL value comparison. The Agency believes that the analysis of hazard to the fetus should be considered in terms of an analysis of fetal exposure vs. fetotoxicity, rather than exclusively in terms of a comparison of the fetal hazard to that of some other hazard, such as maternal toxicity.

Rebuttal Comment 5: Interpretation of Reduced Mouse Litter Size (1, 18)

The American Wood Preservers Institute and Dow Chemical Company contend that the study of Fahrig et al. (1978), reporting decreases in litter size of female mice after intraperitoneal injection of 50 and 100 mg/kg penta, cannot be relied upon for three reasons: 1) evidence of pregnancy was not obtained, i.e., the absence of a litter may have been due to lack of pregnancy, 2) a vehicle control was not used, and 3) the route of administration (intraperitoneal injection) bears no relationship to the routes of human exposure to penta wood preservatives or to treated wood.

Agency Response: The Agency agrees that the Fahrig et al. (1978) study is not primarily concerned with fetotoxic or teratogenic effects. Indeed, this study is basically an examination of the mutagenic potency of the chlorophenols and chlorophenol impurities. The conclusions of the study are based upon the observed frequencies of various color spots in the coats of mice. As such, the authors' comment of "decreased litter size" is unaccompanied by supporting data or procedural information which would normally be essential to a study in which litter-size observation was part of the formal protocol. Therefore, the Agency agrees that "decreased litter size" should be considered an ancillary comment rather than as supporting data.

The Agency also agrees that the lack of a vehicle control makes accurate interpretation of the results of this study difficult, as the toxicity of the vehicle (dimethylformamide) was not characterized by the authors.

Although the Agency generally does not use the results of intraperitoneal experiments as the sole basis for an RPAR notice, studies of this kind (e.g., Fahrig _et al_., 1978) can provide valuable supporting information.

c. Summary of Rebuttal Comments Concerning Fetotoxic and Teratogenic Effects: Conclusion

The rebuttal comments do not rebut the presumption of fetotoxicity for penta, nor the teratogenicity and fetotoxicity caused by HxCDD. The Agency agrees with the rebutters that pure penta is not a teratogen.

Although Schwetz _et al_. (1974) reported a NOEL of 5 mg/kg/day for purified penta, the Agency believes the delayed skull ossification observed at this level is significant. Thus, as this study has not been invalidated, fetotoxicity was demonstrated at the lowest dose tested.

Furthermore, the HxCDD teratology data of Schwetz _et_ _al_. (1973) are still valid and demonstrate the teratogenic and fetotoxic effects of this chemical at doses above 0.1 ug/kg/day.

Additional studies, received by the Agency since completion of PD-1, are discussed in Section II.D.5.ii.

2. Analysis of Rebuttal Comments Concerning Human Exposure

a. Basis of Analysis

As in the preceeding rebuttal analysis (Section II.D.1), thisanalysis of rebuttal comments is based on the formal rebuttals and additional information received since the original publication of PD-1. The numbers after the title of each rebuttal comment correspond to the rebutter numbers listed in Appendix __.

In PD-1, the Agency estimated dietary, inhalation, and dermal exposure to penta and HxCDD on a "worst-case" basis. These estimates were based on the exposure of a pregnant woman in the home and at work at major penta work sites (i.e., wood treatment plants and construction sites). In accordance with the information available in 1978, the Agency made the following assumptions:

a) weight of a pregnant woman = 60 kg

b) absorption by the lungs = 100%

c) dermal absorption = 10%

d) area of the hands = 0.25 ft^2

e) during brush application, a homeowner may spill enough solution to cover one hand (= 10 ml)

f) a woman resides an average of 20 hours/day in her home with a breathing rate of 1.0 m^3/hr

g) 6 months after pressure treatment, penta will be on the wood's surface at a concentration of 0.5 mg/ft^2

h) a construction worker handles wood 40 times per 8-hour work shift

i) breathing rate for workers at construction sites and at treatment plants = 1.8 m^3/hr

The only data available for PD-1 on the vaporization of penta from treated wood in an enclosed area was that of Gebefugl et al. (1976). They found as much as 0.16 mg/m^3 penta in the air of a test area treated with paint containing penta. (The concentration of penta in the paint was not reported.) Consequently, this figure was used to estimate the worst-case exposure situation at home.

In February, 1976, NIOSH conducted an environmental survey of a pressure treatment plant in Little Rock, Arkansas. This study (NIOSH, 1977) included air sampling for penta at various sites in the plant area. Table II.D-2 shows the results of these analyses. For a worst-case estimate, it was assumed that the highest concentration of penta reported, 8 ug/m^3, was present throughout the plant. This same figure was used to calculate the exposure estimate for construction workers.

The exposure estimates for penta and HxCDD in Table II.D-3 are taken from PD-1.

b. Analysis of Specific Rebuttal Comments

TABLE II.D-2

Pentachlorophenol Air Concentrations at a Pressure Treatment Plant[a]

Operation	Sampling Period (min)	Type of Sample[b]	Penta Air Level (mg/m^3)
Hand Mix Oper. A	112	GA	0.004
Hand Mix Oper. B	112	GA	0.004
Sampling Man	EQUIPMENT FAILURE - VOID		
Asst. Treater	442	P	0.001
Laborer A	445	P	0.001
Laborer B	438	P	0.006
Treating Oper.	437	P	0.001
Locomotive Oper.	339	P	<0.001
Hand Mixer	110	P	0.008
Hand Mix Oper.	112	GA	0.003

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a. From NIOSH (1977).
b. GA = General Area; P = Personal.

TABLE II.D-3

Estimates of Human Exposure to Penta and HxCDD[a]

Site	Penta (ug/kg/day) Dermal	Inhalation	HxCDD (ug/kg/day) Dermal	Inhalation
Home	833	53.3	0.0033	0.00021
Construction Sites	8.33	1.92	0.000033	0.0000077
Pressure Treatment Plants	8.33	1.92	0.000033	0.0000077

a. From EPA (1978).

Rebuttal Comment 1: Fixation of Penta (1)

The American Wood Preservers Institute suggests that release of penta into the environment is limited since penta is impregnated into the wood.

Agency Response: It is well established that penta is not permanently fixed within treated wood, and that penta depletion from treated wood is an ongoing process (Walters and Arsenault, 1971). Penta volatilizes from treated wood for some time after treatment (Thompson et al., 1979; Whitney and Gearhart, 1979) and the available information does not preclude volatilization for the lifetime of the treated wood. Environmental exposure to penta is "limited" only in the sense that it is not applied directly to the environment, as a broadcast pesticide would be applied. Penta is found in the environment, and available data demonstrate that penta-treated wood is a source of this contamination (see Section II.D.3).

Rebuttal Comment 2: Source of Penta Residues in Human Urine (18, 252)

PD-1 cites monitoring surveys in several U.S. locations which found measurable penta in the urine of the general population and in a variety of environmental samples. Dow Chemical Company and the University of California Cooperative Extension Service suggest that these residues may not have wood preservative penta as their source. Instead, they suggest three indirect sources and one direct source. According to the rebutters, the most likely source of penta in environmental samples is an indirect source, the breakdown of hexachlorobenzene (HCB). Other compounds, such as pentachloronitrobenzene, lindane, and pentachlorobenzene, are also known to degrade to penta in the environment and are thus other indirect sources.

Furthermore, they state lower chlorinated phenols are known to form penta in water containing chlorine under mild pH conditions (Smith et al., 1976). This evidence supports the possibility that penta is formed in effluents from municipal wastewater treatment as suggested by Detrick (1977). Finally, a direct source of environmental penta is from the widespread use of penta in or on common items, such as paint, cordage, textiles, wallboard, and other products.

Agency Response: The suggestion that the most likely source of penta in environmental samples is the breakdown of hexahcloro-benzene (HCB) or other compounds warrants consideration. HCB occurs in the environment from its very minor use as a pesticide, or more probably as a byproduct of several industrial processes. The appearance of penta in the excreta of experimental animals following HCB administration is reasonably well established. Mehendale et al. (1975) found that 7 days after a single oral dose of ^{14}C-labeled HCB to adult male rats, about 16% of the dose was excreted unchanged in the feces and less than 1% in the urine. Trace amounts of pentachlorobenzene, tetrachlorobenzene, pentachlorophenol, and four unknown products were detected in the urine. The investigators also showed that microsomal preparations from rat liver were able to produce one or more chlorophenols, including penta.

Engst _et_ _al_. (1976) administered 3 mg HCB/kg body weight to rats for 19 days and found penta to be the major metabolite, although they also found small amounts of 2,3,4,6- and 2,3,5,6-tetrachlorophenol, 2,4,6-trichlorophenol, and pentachlorobenzene. Preliminary evidence from Yang _et_ _al_. (1975) suggests that intravenously injected HCB may possibly be converted to penta in the rhesus monkey.

In addition to the mammalian metabolism of HCB to penta, HCB is reported to slowly convert to penta in model ecosystem experiments (Lu _et_ _al_., 1978). These investigators have reported that, following addition of radio-labeled HCB added to their terrestrial-aquatic and aquatic ecosystems, 4.8% and 0.9%, respectively, of the total radioactivity recovered in water was present as penta.

In addition to the _in_ _vivo_ production of penta from HCB, other organic compounds produce penta as an intermediate metabolic product. Karapally _et_ _al_. (1973) _tentatively_ identified penta by gas chromotography in urine as a minor metabolite of lindane in the rabbit. Engst _et_ _al_. (1976) have reported that lindane was excreted in a free state in considerable amounts in rat urine. The major metabolites, which were also identified in urine, were penta, 2,3,4,6-tetrachlorophenol, 2,3,5,6-tetrachlorophenol, and 2,4,6-trichlorophenol.

There is now no compelling evidence that humans synthesize enough penta from other organic compounds to explain current monitoring data. It is possible, however, to derive quantitative estimates of HCB conversion efficiency in the rat. Based on these estimates, it is then possible to calculate (see Table II.D-4) the HCB exposure required to yield the prevailing penta levels in human urine (Kozak, 1980). The Agency believes it is very unlikely for the general population to be exposed to these high levels of HCB.

Some portion of the penta contamination reported in both human and environmental samples can be ascribed to degradation of HCB and other organic compounds. The Agency feels that it is unwarranted, however, to assume that all or even a major part of this contamination results from such processes. It is not possible, at present, to estimate the quantity of penta which does result from metabolism of other compounds in the environment.

The literature contains frequent suggestions that penta may be synthesized as a result of municipal chlorination of drinking water or wastewater. Although this has yet to be established, available data suggest that such a process could be occurring. Smith et al. (1976) failed to detect highly chlorinated phenols following the reaction of 2,4,6-trichloro-phenol with chlorine

TABLE II.D-4

Caculated Estimates of HCB Needed to Produce Observed Urinary Levels of Penta

Observed Urinary Penta Level (ppm)	Total Penta Eliminated in Urine[a] (mg/day)	HCB Needed (mg/person/day) with Conversion Efficiency of: 0.2%	2.0%
0.040[b]	0.056	28	2.8
1.8[c]	2.5	1200	130
0.0063[d]	0.0088	4.4	0.44
0.193[e]	0.27	140	14

a. Average human urinary elimination volume = 1.4 liter/day.
b. Average level found by Bevenue *et al*. (1967) in Hawaii.
c. Maximum level found by Bevenue *et al*. (1967) in Hawaii.
d. Average level found by Kutz *et al*. (1978) in continental U.S.
e. Maximum level found by Kutz *et al*. (1978) in continental U.S.

in dilute aqueous solution, although a number of highly chlorinated nonphenolic products were identified. Chlorination of 4-nitrophenol in the same system yielded small amounts of 2,3,4,6-tetrachlorophenol and 2,6-dichloro-4-nitrophenol. Penta was not detected. Chlorination of 2,3,4,6-tetrachlorophenol in a separate experiment yielded significant quantities of penta. The combined results of the two experiments suggest that penta may eventually be produced from chlorination of 4-nitrophenol; however, the process was not directly detected by these investigations.

In more recent research, Smith and Lee (1978) studied the reaction of dilute aqueous solutions of hypochlorous acid with 2,6-dichloro-, 2,4-dichloro-, and 2,4,5-trichlorophenol. Although extensive chlorination and oxidation of the phenols were observed, penta was not detected in the reaction mixtures. Larson and Rockwell (1979) have demonstrated that a number of naturally occurring carboxylic acids react in dilute solution with aqueous hypochlorite to form chlorophenols. The most highly chlorinated compound detected was 2,4,6-trichlorophenol. Neither tetrachlorophenol nor penta was detected. A single report in the literature alleges that penta may be synthesized from phenol through the chlorination process. Detrick (1977) claims to have found that the chlorination of 1 ppm of phenol in water by 10 ppm of chlorine leads to the production of about 0.2 ppb of penta. Unfortunately, neither the experimental protocol nor the analytical method was provided in the Detrick report, so this report cannot be accepted without further confirmation.

Thus, direct production of penta following chlorination processes in the environment has never been demonstrated. In view of the tenuous nature of the data supporting the hypothesis, penta production by municipal or commercial chlorination is unsubstantiated.

Finally, it has been proposed that penta in human urine originates from non-wood uses of penta. It is difficult to assess the relative contribution of the nonwood preservative uses of penta to prevailing environmental levels. Much of the penta that is not consumed in wood-treating processes is used for slimicidal purposes in various industrial settings. In these cases it is applied as the water-soluble salt. Pulp and paper mills, tanneries and other industrial processes rich in organic material require such control measures.

Penta is also used in significant amounts as a preservative for adhesives, rubber, textiles, oils, and other materials. Some of these uses provide more frequent opportunity for direct contact with the chemical by the general public. In general, however, the incorporation of penta as a preservative in these products should result in exposure potential quantitatively similar to that of treated wood. The resulting exposure from this group of sources would be expected to reflect the quantity of penta used in such applications. Hence, there is not sufficient reason to assume that non-wood preservative uses contribute a major portion of the observed environmental penta loads. Such sources may well account for some portion of the ambient environment concentrations. However, without data to the contrary, common sense suggests that these portions are related to the amount of penta used for such applications; nonwood pesticidal uses of penta comprise only 10 to 20% of the total penta production.

Rebuttal Comment 3: Air Pollution as Mechanism for Penta Contamination (221)

Friends of the Earth suggests that air pollution may account for much of the penta contamination.

Agency Response: No direct data on penta levels in ambient air are available. Circumstantial evidence was provided by Bevenue *et al*. (1972) who found levels of penta in rainwater collected in Hawaii ranging from 2 to 284 ng/liter. The penta in rainwater likely came from washout of the chemical present in the atmosphere either as vapor or as an occlusion on dust particles. Penta volatilizes from the surface of freshly treated wood (Gebefugl *et al*., 1976; Thompson *et al*., 1979) and appears to vaporize from treated wood which has been in service for several years (Whitney and Gearhart, 1979). Information on the transport and persistence of penta in air is not available. At the present time, the lack of air monitoring data precludes definitive conclusions regarding the rebuttor's suggestion, but it does seem likely that some penta contamination of the air may occur. The extent to which this process contributes to the prevailing environmental levels remains speculative.

Rebuttal Comment 4: Analytical Interference (278)

Forshaw Chemical Company claims that measured background levels of penta may not actually be penta, since naturally occurring chemicals interfere with penta analysis.

Agency Response: Naturally occurring chlorinated aromatic organic compounds are produced only rarely in the environment; when this occurs at all, the compounds are usually fungal antibiotics produced by marine species (Siuda and DeBernardis, 1973). Pierce (1978) measured 0.3 ppb penta in water and 3 ppb penta in sediment from ponds as a control. The presence of penta was confirmed in these samples by mass spectrographic analysis. While the rebutter may be correct in implying that naturally occurring organic compounds may mimic penta in gas chromatographic analyses, confirmation of penta's identity by retention time on two different columns and by mass spectral analysis gives definite confirmation of the presence of penta at these low level samples. Although naturally occurring organic compounds may mimic the retention time on one gas chromatographic column, it would be less likely to do so on two different ones, and would definitely not give a mass spectrum identical to that of penta. Also, the rebuttor did not provide examples of compounds that would be indistinguishable from penta on two gas chromatographic columns. For these reasons, the

Agency rejects the rebuttor's comment.

Rebuttal Comment 5: Mechanical Handling of Treated Wood (18)
Dow Chemical Company states that dermal exposure is negligible during pressure treatment because the treated wood is handled mechanically.

Agency Response: The Agency agrees with this rebuttal comment for the actual treatment process. In plants visited and in discussions with industry representatives, it is apparent that for pressure treatment facilities, wood is handled mechanically (forklift, stackers, etc). For subsequent handling, wood may or may not be moved mechanically. If moved manually by workers with gloves, then exposure is negligible, but the rebutter has not demonstrated that all operations are mechanical, nor that workers wear gloves at all times during manual operations. Thus, dermal exposure is still possible.

Rebuttal Comment 6: Protective Gloves and Treated Wood (1, 18)

The American Wood Preservers Institute and Dow Chemical Company claim that dermal exposure to construction workers from the handling of pressure-treated wood is negligible because: 1) the wood is dry, and 2) the workers wear gloves.

Agency Response: The Agency believes there are many cases when gloves are not worn. Also, data from Koppers Chemical Company indicate that as much as 0.5 mg/ft^2 penta is on the surface of pressure-treated wood 6 months after treatement.

Rebuttal Comment 7: Protective Gloves and Sapstain Control (4)

Chapman Chemical Company claims that exposure to sodium penta resulting from sapstain treatment is negligible because the wood is handled mechanically and because gloves are worn.

Agency Response: The Agency agrees that dermal exposure is not significant if treated wood is handled only mechanically. In an Agency memorandum about a site visit by Agency personnel to observe sapstain treatment, it was concluded that treated wood is generally handled automatically during treatment (conveyor systems, etc.) and that human contact is slight.

Subsequent stacking and handling is done in most cases by workers wearing gloves. However, unlike pressure treatment in which treated wood is generally not handled while it is wet (see comment 5), sapstain treatment does result in wet wood. Thus,there is the possibility of exposure while handling the treated wood even when wearing gloves. The PD-2/3 exposure analysis provides estimates of dermal exposure to sapstain workers with or without gloves.

Rebuttal Comment 8: Dermal Retention (18, 252, 254, 481)

Dow Chemical Company, the University of California, Vulcan Chemical Company, and the National Forest Products Association provided comments to refute EPA's estimate for exposure to penta from application of 5% penta. The Agency assumed that 10 ml of solution would adhere to the surface of one hand. Dow states that Weaver (see Dow Chemical Company, 1978) shows water retention on a women's hand to be 3 ml. Vulcan also estimated 3 ml as a maximum amount. The University of California rebuttal claims that since penta is a skin irritant, an applicator would quickly wash it off, and there would be little dermal absorption.

Agency Response: In view of the experimental data supplied by Dow, the Agency agrees that 3 ml is a reasonable estimate of the quantity of solution which would adhere to the skin of a human hand. The Agency does not accept the point that penta would invariably be removed quickly enough to prevent any absorption.

Rebuttal Comment 9: High Dermal Absorption Rate (278)

Forshaw Chemical Company states that EPA's estimate of 10% dermal absorption is too high. The rebutter did not supply evidence to refute this estimate.

Agency Response: From the Agency's Pesticide Incident Monitoring System data, it is readily apparent that penta can be absorbed through the skin. Listed incidents detail skin contact that resulted in a systemic intoxication to the users. Thus it is clear that penta is absorbed through the skin. The rate of absorption is not known. The rebuttal comment, claiming 10% absorption was too high, did not supply evidence to the contrary. The absorption estimate of 10%, based on the results of Maibach and Feldman (1974) with several chlorinated hydrocarbons, will be retained until evidence is supplied showing the Agency's estimate to be in error.

Rebuttal Comment 10: Dermal Absorption of Sodium Penta (252)

The University of California comments that sodium penta is more slowly absorbed than the lipid-soluble penta molecule. (In aqueous solutions, most of the penta is present as the pentachlorophenate ion.) The rebutter believes that, when calculating the dose of sodium penta absorbed through the skin, the proper absorption factor would be lower than that used for calculating penta absorption.

Agency Response: Data on rabbits (Kehoe et al., 1939) suggest that the hazard from continuous dermal dosing with 1 to 2% aqueous sodium penta is not greatly different from the hazard of the same treatment with penta in mineral oil. Also, a recent review of the literature (Kozak et al., 1979) clearly indicates that cutaneous application of sodium penta is lethal to test animals. The Agency is not aware of experimental data which would rebut the use of 10% as a reasonable dermal absorption factor for calculating dermal absorption from repeated exposure to sodium penta.

Rebuttal Comment 11: Absorption of Penta by Inhalation (18)

Dow Chemical Company states that the EPA assumption "that a chemical is 100% absorbed by inhalation exposure is not supported by the literature." The rebutter believes that 70% respiratory absorption of penta is a more accurate figure than 100%.

Agency Response: In the absence of adequate quantitative data on penta inhalation, the Agency continues to believe that 100% inhalation absorption is a reasonable estimate of a worst-case situation. Furthermore, the study of Hoben et al. (1976) presents data, albeit incomplete, apparently showing greater than 70% inhalation absorption in the rat.

Rebuttal Comment 12: Inhalation Exposure During Sapstain Treatment (4, 252)

Chapman Chemical Company and the University of California claim that inhalation exposure is negligible during sapstain treatment operation because evaporation of sodium penta is negligible, and because spray is not generated.

Agency Response: Inhalation exposure may be significant during sapstain treatment operations since sapstain preservative solutions may be applied to lumber by either dip or by spray. The Agency agrees that volatilization of penta from aqueous sodium solutions is likely to be extremely small. Since these solutions are basic, the penta is largely present in the nonvolatile salt form. Sapstain solutions, however, are often applied by spray methods and available data indicate that measurable amounts of airborn penta are detectable in the vicinity of spray operations. The maximum reported penta air concentration in close proximity to the spray booth was reported as 69 ug/m^3 by Arsenault (1976) and as 4 ug/m^3 by the National Forest Products Association in their rebuttal to PD-1. The 69 ug/m^3 air level will be used to derive a maximum predicted inhalation exposure in the exposure analysis.

Rebuttal Comment 13: Women's Breathing Rate (1, 18, 481)

The American Wood Preservers Institute, Dow Chemical Company, and the National Forest Products Association, state that the respiratory rates for women cited in PD-1, 1.8 m^3/hr, are unrealistically high, resulting in an overestimate of human inhalation exposure. They suggest that a more probable breathing rate for a woman is 1.0 m^3/hr (Altman *et al*., 1958).

Agency Response: The Agency acknowledges that the breathing rates cited in the PD-1 may overestimate inhalation exposure among the population group at risk (i.e., women of child-bearing age). Consequently, the following respiratory rates for women have been abstracted from Altman et al. (1958) and will be used for development of the PD-2/3 exposure analysis:

resting - 0.27 m^3/hr

light work - 0.98 m^3/hr

heavy work - 1.47 m^3/hr

Rebuttal Comment 14: Inappropriate Use of Inhalation Measurement (18)

Dow Chemical Company claims that to derive an exposure estimate, the Agency simply used the same inhalation exposure figure calculated for pressure treatment plant workers. That figure was based on the airborne concentration of penta found next to the plant hand mixer, as measured by NIOSH in 1976. It is improper to use an inhalation exposure number found during a high exposure plant operation, when the wood has been freshly treated, as an estimate for construction workers. Inhalation exposure to a construction worker, after the penta has been impregnated into the wood, would be negligible.

Agency Response: Penta depletion from treated wood has been recognized for many years (Walters and Arsenault, 1971), but the precise mechanism for the depletion has not been ascertained. Available data (Thompson et al., 1979; Whitney and Gearhart, 1979) suggest that volatilization of penta from treated wood occurs for time periods well in excess of 6 months and that such processes may occur for many years. No information presently exists to suggest that penta is permanently bound into treated wood. Thus construction workers are expected to incur some degree of penta exposure via inhalation.

The Agency agrees that air levels measured during commercial wood treatment may not be appropriate for construction workers. Hence, the air levels used for construction worker exposure in PD-1 will not be used in PD-2/3. Rather, the penta air levels reported by Wyllie et al. (1975) in the wood storage area of a small wood treatment plant in Idaho are deemed more appropriate for the estimate of construction worker inhalation exposure in most instances. It is believed that occupational exposure to treated wood may occasionally occur in poorly ventilated settings such as storage sheds, railroad cars, and warehouses. For these settings, air levels derived in volatilization experiments (Thompson et al., 1979) with treated wood will be used in the Exposure Analysis.

Rebuttal Comment 15: Margin of Safety for Inhalation Exposure (1)

The American Wood Preservers Institute claims that there is already an ample margin of safety for the application and use of penta as a wood preservative. This claim is supported by the OSHA Threshold Limit Value (TLV) for penta, which already includes a regulatory margin of safety. The air concentration data used by EPA to assess treatment plant exposure indicate that air levels rarely approach even the OSHA standard; when levels do approach the OSHA TLV, it is only under unusual circumstances.

Agency Response: The fact that penta air levels in commercial plants rarely exceed the OSHA TLV of 0.5 mg/m^3 does not necessarily indicate that an adequate margin of safety exists. The OSHA TLV was promulgated to ensure that inhalation exposure to penta would not be acutely toxic. The toxic effects in question for the RPAR of penta are chronic in nature and margins of safety will be developed by the Agency based on these effects.

Rebuttal Comment 16: Inhalation Exposure to Homeowners and Farmers (4, 18, 278)

Chapman Chemical Company, Dow Chemical Company, and Forshaw Chemical Company state that inhalation exposure calculations should be limited to the time spent during application in a well-ventilated area. Since homeowners are unlikely to use penta more than a few times a year, their exposure to penta via inhalation will be intermittent.

Agency Response: Human inhalation exposure resulting from the application of over-the-counter penta formulations may take two forms: inhalation during the application phase, and inhala- tion of vapors or particulates from the surface of the treated wood after application. The Agency agrees that most applica- tions of these products by homeowners and farmers will take place outdoors during treatment of decks, fenceposts, wood siding, and other exterior wood structures.

Inhalation exposure to penta vapors or particulates from exterior surfaces of treated wood following application to exterior structures is expected to be extremely low. The Agency agrees that when penta is applied to wood in a well-ventilated area, and when the treated structure remains outdoors, the human inhalation exposure will be "intermittent" in nature, since homeowners or farmers would be expected to apply penta formulations to new or existing wood for a short time once every several years. An exception to this might be the case of a farmer who carries out much of his penta application over a single extended period every few years or engages in an intensive dipping operation for fence posts when a fence is replaced or installed. If, however, penta formulations are applied on the inside of wooden structures (barns, storage sheds, homes, etc.), exposure to vapor or to particulates will occur both during and following the application phase (see comment 17). Thus, while it is true that in many situations homeowners' and farmers' exposure to penta will be intermittent, this is not always the case.

Rebuttal Comment 17: Homeowners' and Farmers' Inhalation Exposure in Enclosed Areas (4, 18, 278)

Chapman Chemical Company, Dow Chemical Company, and Forshaw Chemical Company state that EPA calculated inhalation exposure based on a study where paint containing penta was used to treat wood in an enclosed area, and then assumed that a woman could be exposed for 20 hours a day.

They state that labels on consumer products containing penta warn against the products on interior wood and direct the user to ensure adequate ventilation during application. Users that violate label directions should not be considered to be practicing "widespread and commonly recognized patterns of use." Estimates of inhalation exposure should not, therefore, be based on concentrations in enclosed areas within the home.

They further state that the evidence used for this exposure estimate is not suitable for quantitative analysis. At most, one might conclude that penta solutions should only be used on interior wood that is to be finished with a coating. In addition, the penta volatilization rate will be markedly reduced after it dries.

Agency Response: The Agency has information (PIMS, 1978) indicating that penta formulations and penta-treated wood are used inside homes, and this may result in continuous exposure to penta air levels which exceed the levels detected in many commercial settings (see Section II.D.3.b.ii).

A point which has been made by several rebuttors is that penta should not be used on interior wood of homes and that such practice is a "misuse" or an "imprudent use" and hence not a concern of the regulatory process. If all over-the-counter products containing penta possessed labels prohibiting use inside homes or on structures where constant dermal contact by humans was likely, the point would have some merit. However, many currently registered products do not possess labels which contraindicate such usage. As a consequence, application of these products in homes cannot be considered a "misuse" from either a legal or practical standpoint. For instance, in a case of penta poisoning in California following use of penta in a home (EPA, 1978), label directions on the formulation used did not caution against indoor use.

The extent of human exposure from such use depends on the type of structure (home vs. barn), the degree of ventilation, temperature, the length of time spent in the structure, and many other variables. Since many labels of over-the-counter penta formulations sold do not warn against use in enclosed structures (including homes), use of such products according to label instructions may result in significant penta levels within human habitations. Exposure times as high as 24 hours are reasonable for worst case analysis of such a situation.

In the worst-case analysis developed in PD-1, 0.16 mg/m^3 was used as a maximum expected air concentration from volatilization of penta from treated wood. This penta air level is realistic, despite the fact that it was taken in an unventilated room at 29°C (84°F). In the absence of air exchange, the equilibrium vapor density of penta at 25°C would lead to a predicted air level of 2.2 mg/m^3. Laboratory results of

Thompson et al. (1979) conducted in a cylinder with a 2% air exchange rate per minute at 25°C indicate that penta levels of 0.025 to 0.040 mg/m^3 may occur due to volatilization from pressure treated lumber. In California incidents where the interiors of homeswere heavily treated with penta occupants became ill, the penta air concentrations ranged from 0.5 to 30 ug/m^3 (Mengle, 1980).

Many log homes in this country have been constructed with logs treated with penta. This Agency recently cooperated with the Center for Disease Control in a study of penta levels in residents of Madison Couny, Kentucky (see Section II.D.4.b). In the course of this study two air samples were obtained from a single log home, the logs of which had been treated with penta. These air samples contained 0.20 and 0.38 ug/m^3 penta.

So far, this discussion concerns only the level of penta vapor that may occur in enclosed spaces. If significant blooming of crystalline penta were to occur, penta dust and particulates could become airborne as a result of housecleaning and other activities. The resulting penta inhalation exposure would then be a combination of vapor and dust exposure. A precise quantitation of the dust exposure in such settings is not possible.

Although human inhalation exposure during indoor application of penta formulations may be intermittent, exposure following application in enclosed spaces may occur for an indefinite period of time. Hence, a worst-case approach may justifiably assume a continuous (24 hour), rather than an intermittent, exposure.

There is no evidence to indicate that the penta volatilization rate will be reduced by the drying of wood treated with over-the-counter penta formulations. In fact, recent experiments (Thompson et al., 1979) indicate that penta volatilization from treated wood may occur for an extensive time period (greater than 6 months) after treatment. Although these experiments were conducted with pressure-treated wood, the Agency believes, in the absence of evidence to the contrary, that penta will volatilize for an extended period of time from wood surfaces treated with over-the-counter products.

The use of paints or sealants has yet to be adequately addressed. Preliminary laboratory work by Thompson et al. (1979), however, indicates that oil and water-based paints may reduce (but not eliminate) penta volatilization from pressure treated wood.

Rebuttal Comment 18: Alternative Exposure Analysis (481)

The National Forest Products Association rebuttal contains an extensive exposure analysis which differs substantially from the Agency analysis in PD 1. Dermal, oral, and inhalation exposure of workers and members of the general population using penta formulations were estimated for two situations: a "worst-case analysis," which the rebutter believes represents short-term worker exposures occurring infrequently, and "average" exposure values which are believed to exemplify typical day-to-day exposures. Assumptions for the worst-case analysis are:

a) individual's weight = 70 kg
b) absorption by the lungs = 70%
c) dermal absorption = 10%
d) average area of the hands = 0.25 ft^2
e) gloves are not worn
f) an 8-hour work shift consists of 4 hours at heavy breathing rate (2.52 m^3/hr) and 4 hours at a moderate breathing rate (1.0 m^3/hr)

Also, this exposure analysis uses the maximum reported air concentration found in the literature.

The assumptions for the average worker exposure which differ from those for the worst-case analysis are:

a) gloves are worn
b) an eight-hour work shift consists of eight hours at a moderate breathing rate (1.0 m^3/hr)

For this analysis the average reported air concentrations found in the literature are employed.

Agency Response: Absorption of penta by the dermal and inhalation routes is discussed elsewhere in this rebuttal analysis (see comments 9, 10, and 11). The Agency has decided that 60 kg is a more typical weight for a female worker. Also, the Agency has selected 0.98 m^3/hr and 1.47 m^3/hr as the breathing rates most appropriate for a female worker at light and heavy work, respectively (Altman _et_ _al_., 1958). The PD-2/3 exposure analysis will be developed for a reasonable upper limit of exposure. Consequently, for the calculations in this analysis, the Agency makes these assumptions:

a) individual's weight = 60 kg
b) absorption by the lungs = 100%
c) dermal absorption = 10%
d) average area of the hands = 0.25 ft^2
e) gloves are not worn
f) an eight-hour work shift consists of six hours at a moderate breathing rate (0.98 m^3/hr) and two hours at a heavy breathing rate (1.47 m^3/hr)

Rebuttal Comment 19: Overestimation of Exposure Potential (18) Dow Chemical Company states that EPA overestimates the theoretical potential exposure for the general population by dividing the total annual penta production by the number of people in the general population.

Agency Response: The Agency agrees that this method of exposure estimation is inappropriate. Consequently, this procedure is not followed in this PD-2/3.

Rebuttal Comment 20: Market Basket Survey Results (252)

The University of California Cooperative Extension Service claims it is inappropriate for EPA to average the Market Basket Survey results in food over the entire diet, stating that it is improper to average the content of a few samples positive for penta over an entire group of samples in each category.

Agency Response: Table 12 of PD-1 provides an estimate of dietary penta from several major food categories. The Agency believes these average and maximum values for penta are entirely appropriate because the estimates are based on measured residues in the major food categories, and the average intake estimates are based on Department of Agriculture studies.

The rebutter points out that some of the food categories may have had only a few samples positive for penta (e.g., 1 of 20). The Agency did not intend to state that all samples contained penta, but rather that these figures are useful in estimating a possible average of dietary intake. Also, it is theoretically possible for fetotoxic effects to result from a single exposure to a fetotoxic agent, if a fetotoxic dose is administered during the critical time of gestation. Thus, the Agency does not accept the rebutter's comment as valid.

Rebuttal Comment 21: Misuse (18)

The Dow Chemical Company suggests that abnormally high levels of penta reported in worker's blood reflects misuse.

Agency Response: In PD-1 (page 10), the Agency cited a paper by Arsenault, in which blood of wood treatment workers in a pressure plant was measured for penta. It was found that of the occupationally exposed workers, the wood treaters (21 people) had the highest mean level of penta in the blood stream (1.05 ppm). Other workers in pest control occupations had lower levels of blood penta. The control group had blood plasma levels of 0.1 ppm penta. This reference indicates that wood treaters using penta have average blood levels 10 times higher than a control group.

The claim that misuse is the cause of high levels of penta in the blood of workers is a moot point because, first, if it is in fact misuse, then more stringent controls may need to be implemented to lower exposure and, second, if it is not misuse, then health standards still have to be strengthened. The Agency thus rejects the rebuttal comment because more controls for reducing exposure appear to be needed in any case.

Rebuttal Comment 22: Exposure of Pregnant Women (278)

Forshaw Chemical company claims that use of the term "pregnant woman" is unnecessary, prejudicial, and discriminatory unless it can be shown that pregnant women are exposed to significantly different levels of penta.

Agency Response: Use of the term "pregnant woman" is entirely appropriate in this instance. The RPAR criteria presented in PD-1 for penta were teratogenicity and fetotoxicity. Consequently, the only members of the human population at risk are women who are pregnant. It is reasonable to develop an exposure analysis based on susceptible members of the population at risk. However, henceforth in this PD-2/3 the phrase "women of child-bearing age" will be used in place of "pregnant woman."

Rebuttal Comment 23: Penta Residues in Higher Plants (221)

Friends of the Earth criticizes PD-1 for stating that "there are no data on penta residues in higher plants *resulting from its use as a pesticide*." This rebutter cites a report by Haque *et al*. (1978) indicating that rice plants in the laboratory, following treatment of the soil at an application rate corresponding to agricultural practice, can absorb penta.

Agency Response: The PD-1 statement mentioned by the rebutter is correct as it stands. There are still no data on penta residues in higher plants resulting from its use as a pesticide. Laboratory studies which show that penta may be absorbed by vascular plants are merely indicative that such processes *may* occur in the environment. Nevertheless, the report presented by the rebutter (Haque *et al*., (1978)) is valuable in that translocation of penta from the soil to the foliage of rice plants was demonstrated in the laboratory. Whether such a process in the environment causes significant residues in edible portions of vascular plants is not known, nor is it known how the wood preservative uses of penta might contribute to these possible residues.

Rebuttal Comment 24: Penta Residues in Human Seminal Fluid (221)

Friends of the Earth criticizes PD-1 for failing to mention that penta residues have been detected in human seminal fluid by Dougherty and Piotrowska (1976).

Agency Response: The results of Dougherty and Piotrowska (1976) were mentioned in PD-1 on page 11.

3. Revised Human Exposure Analysis

a. Assumptions and Methods

All exposure estimates in this analysis are based on these assumptions:

a) weight of a woman of child-bearing age = 60 kg
b) absorption by the lungs = 100%
c) dermal absorption = 10%
d) breathing rate at rest = 0.27 m^3/hr
e) breathing rate during light work = 0.98 m^3/hr
f) breathing rate during heavy work = 1.47 m^3/hr

Inhalation exposure, which results from absorption of chemicals across the alveolar respiratory membrane, can be determined from measurements of the amount of chemical in the air. Concentrations in air are expressed as either parts per million (ppm) or weight of chemical per cubic meter (m^3) of air. The amount of air actually entering the lung per minute (minute alveolar ventilation) is determined, then multiplied by the number of minutes of exposure and by the air concentration. The resulting exposure is expressed as weight of chemical per kg of body weight per day.

There are two major difficulties with this approach. First, minute alveolar ventilation is not constant. Respiratory rates and the amount of air per breath (tidal volume) can change manyfold depending on the level of physical exertion and tissue oxygen demand. Consequently, assumptions need to be made about level of physical activity for a particular type of work. The breathing rates for human females that will be used for this analysis were taken from Altman _et al_. (1958).

The second problem is the physical state of the chemical in the air. If the material is a particulate, that is dust, then the larger particles (those greater than 10 microns in diameter) are either filtered out by the turbinates in the nose or are deposited in the pharynx, trachea, or larger bronchi. Material deposited in these places is removed by ciliary action and the material is gradually moved to the back of the mouth where it is swallowed or spit out. If it is swallowed, oral exposure occurs in addition to inhalation exposure. Smaller particles and vapors reach the deep parts of the lung where they are absorbed into the blood or lymph and are subsequently translocated to the other parts of the body.

Inhalation exposure estimates can be developed in one of two ways. The first method uses the published penta air levels for both occupational and non-occupational settings, assumes a given exercise level, exposure duration, absorption rate and body weight, and then a mg/kg body weight exposure estimate is developed. The second method uses either theoretical penta vapor levels or data derived from laboratory measurements to develop similar estimates. The former method is preferable when enough data are available. Despite the uncertainties inherent in extrapolating from laboratory data to the environment, the second approach can provide valuable information in situations where monitoring data are not available. Both of these methods will be used in this exposure assessment.

In contrast to the large body of data available on air levels of penta associated with wood preservation, from which estimates of inhalation exposure were prepared, very little information is available on actual levels of dermal exposure. PD-1, in fact, relied upon the assumption that dermal exposure in pressure-treatment plants "is at least equal to exposure at construction sites." There were very few rebuttal comments about dermal exposure from wood preservative uses of penta, even though the Agency invited registrants to "provide data and information to confirm, refine, or rebut the information upon which the exposure estimates are based." Review of the available literature on dermal exposure measurements for pesticides, however, yielded additional information which will be used to extend the original estimates given in PD-1.

Exposure to hexachlorodibenzo-p-dioxin (HxCDD) and hexachlorobenzene (HCB) are developed using the same assumptions as for penta. In addition, these assumptions are also made: first, the HxCDD and HCB content of technical penta and sodium penta currently in the market place is 15 ppm and 100 ppm, respectively, and second, exposure to these penta impurities is proportional to the levels of the compounds in technical penta. Using these assumptions, exposure to HxCDD is equal to the penta exposure times the factor 15 x 10^{-6} (15 ppm) and exposure to HCB is equal to penta exposure times the factor 100 x 10^{-6} (100 ppm).

Because the vapor pressure of HxCDD is significantly lower than that of penta (800-fold lower), inhalation exposure to HxCDD has been estimated only for situations where dust or mist formation is likely to occur. HCB, on the other hand, is slightly more volatile than penta. Thus HCB inhalation exposure has been estimated for all situations where respiratory exposure to penta is likely.

It is important to recognize that the estimates of dermal exposure to HxCDD and HCB based on this assumption of proportionality are most reliable when exposure to penta formulations or freshly treated wood occurs. These estimates are less reliable in cases of exposure to treated lumber after weathering, as volatilization and photochemical processes will have occurred which may alter the original proportions of the contaminants.

b. Penta Concentrations Measured in Air

i. Occupational Settings

Penta levels in air have been reported for wood-treated plants (NIOSH, 1975; NIOSH, 1977; Wyllie et al. 1975; Rapp, 1978) and for several nonoccupational settings (Whitney and Gearhart, 1979). These data can be used to estimate respiratory exposures

The penta air levels determined by Wyllie et al. (1975) at a small wood treatment plant in Idaho are given in Table II.D-5.

Rapp (1978) presented the results of a series of industrial hygiene surveys conducted by Dow Chemial Company scientists at 28 users' sites. Penta air levels were determined for three exposure situations: while emptying penta bags, while opening the pressure cylinder door, and while engaged in routine plant activities (see Table II.D-5).

NIOSH (1975) has conducted a health hazard evaluation determination at a major wood-treatment firm in De Queen, Arkansas. As a part of this evaluation, 24 air samples were collected on the premises and analyzed for penta (see Table II.D-5).

Morton and Freed (1973) reported the results of a penta worker exposure study conducted by the Environmental Health Sciences Center, Oregon State University. Air samples were taken at 25 companies using penta as a wood preservative. Seven companies were engaged in dip treatment operations, seven were pressure treatment firms, and eleven used sodium penta as a spray treatment for sapstain control (see Table II.D-5).

Table II.D-6 contains estimates of penta inhalation exposure at various levels of exercise. The assumptions used in the analysis have been given previously. Inhalation exposures were calculated on the basis of the penta air levels in industrial settings previously discussed.

TABLE II.D-5

Penta Air Concentrations at Various Treatment Plant Sites

	Penta Air Concentration (mg/m^3)	
Site	Average Value Reported	Maximum Value Reported
Pressure treatment room[a]	0.006	0.015
Office[a]	0.0018	0.0035
Treated wood storage area[a]	0.00026	0.0026
Penta storage area[a]	0.001	0.0039
Dip tank area[a]	0.0002	0.0008
Emptying penta bags[b]	0.3	18.5 (65)
Opening cylinder door[b]	0.13	13 (150)
General operations[b]	0.004	0.02
Emptying penta bags[c]	0.85	3.83
General operations[c]	0.00007	0.00044
Dip treatment: general grounds[d]	0.019	0.003
maximum exposure area[d]	0.019	0.063
Spray treatment (sapstain): general grounds[d]	0.006	0.012
maximum exposure area[d]	0.026	0.069

TABLE II.D-5 (Continued)

Pressure treatment:		
general grounds[d]	0.014	0.028
maximum exposure area[d]	0.296	1.000

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a. From Wyllie *et al*. (1975).
b. From Rapp (1978); numbers in parentheses are unusually high values.
c. From NIOSH (1975).
d. From Morton and Freed (1973).

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TABLE II.D-6

Estimates of Penta Exposure at Various Treatment Plant Sites

Sites		Estimated Penta Exposure (ug/kg/8 hr) at:		
		Rest	Light Work	Heavy Work
Pressure treatment room[a]:	average	0.216	0.782	1.18
	maximum	0.54	1.96	2.94
Office[a]:	average	0.065	0.235	0.353
	maximum	0.126	0.456	0.686
Wood storage area[a]:	average	0.0094	0.034	0.051
	maximum	0.094	0.34	0.51
Penta storage area[a]:	average	0.036	0.13	0.196
	maximum	0.14	0.51	0.76
Dip tank area[a]:	average	0.0072	0.026	0.039
	maximum	0.029	0.104	0.157
Emptying penta bags[b]:	average	10.8	39.1	58.8
	maximum	2,340	8,476	12,740
Opening cylinder door[b]:	average	4.68	17.0	25.5
	maximum	5,400	19,560	29,400
General operations[b]:	average	0.144	0.522	0.784
	maximum	0.72	2.61	3.92
Emptying penta bags[c]:	average	30.6	111	167
	maximum	138	499	751
General operations[c]:	average	0.0025	0.0091	0.014
	maximum	0.016	0.057	0.086

TABLE II.D-6 (Continued)

Dip treatment[d]:				
general grounds,	average	0.684	2.48	3.72
	maximum	2.27	8.22	12.35
maximum exposure area,	avearge	0.684	2.48	3.72
	maximum	2.27	8.22	12.35
Spray treatment (sapstain)[d]:				
general grounds,	average	0.216	0.782	1.18
	maximum	0.432	1.56	2.35
maximum exposure area,	average	0.94	3.39	5.10
	maximum	2.48	8.99	13.5
Pressure treatment[d]:				
general grounds,	average	0.504	0.83	2.74
	maximum	1.01	3.65	5.49
cylinder door,	average	10.7	387	58.2
	maximum	36	130	196

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a. From Wyllie *et al*. (1975).

b. From Rapp (1978); maximum values are calculated using 65 and 150 mg penta/m^3 figures in Table 1.

c. From NIOSH (1975).

d. From Morton and Freed (1973).

Calculated exposure rates developed in Table II.D-6 range from 0.0025 to 29,400 ug/kg/8-hr. It is important to realize that exposure levels calculated for a heavy exercise level are presented for illustrative purposes only. A heavy exercise level for an entire 8-hour work shift is an unlikely possibility. A light exercise level for 6 hours and 2 hours of heavy work will be used to calculate the maximum predicted daily exposure for a female in an industrial setting. The data indicate that the greatest respiratory exposure may occur when the pressure cylinder door is opened or when workers are engaged in emptying penta bags. The opening of the cylinder door is a separate occurence which takes place, at most, twice per working shift per cylinder. Duration of this activity is expected to be short (less than 20 minutes). The Agency believes it is unlikely that a worker will be involved in this activity for more than 1 hour per day. The remaining 6 to 7 hour penta exposure during a working day would be at the lower background level for plant employees.

Emptying penta bags is an operation for which exposure for a 4-hour period during an 8-hour work shift might be expected (Nicholas, 1980). As a result, the calculated exposure levels in Table II.D-6 may be multiplied by four in order to approximate the actual exposure during bag emptying operations.

It must be emphasized that the analysis above considers inhalation exposure alone. Total human exposure includes dermal and oral exposure as well, and estimates of these levels will be included where possible in order to arrive at an estimate of total daily exposure.

ii. Nonoccupational Settings

Fewer data are available for penta air levels in nonoccupational settings. Much of this information is derived from case studies in which penta formulations or penta-treated wood were used indoors. In a number of cases (California, 1980) where human illness was associated with the use of penta indoors, reported penta air concentrations ranged from 0.5 to 30 ug/m^3.

Whitney and Gearhart (1979) collected and analyzed air samples for penta in four buildings, ranging in age from 3 to 7 years. Treated wood in the structures consisted of 6 in. by 6 in. timbers spaced on 9-ft. centers, with some buildings having 2 in. x 6 in. boards around the lower periphery to support the sheet metal skin. The structures were ventilated by open eaves or louvered gables or both, and air sampling of building #2 was conducted with its large door open. The investigators noted that all the structures studied for the project contained minimal treated-surface-to-enclosed-volume ratios and that ambient temperatures at the time of sampling ranged from 11.5 to 25.0°C. They detected low penta air concentrations in all of the buildings. Table II.D-7 presents their results.

These authors suggest, however, that the penta concentrations observed in their study may represent a low estimate of the

TABLE II.D-7

Penta Air Concentrations in Buildings[a]

Building	Age of Building (months)	Ambient Temp. at Sampling Time (°C)	Number of Samples	Average Penta Concentrations (ug/m^3)
1	8	11.5	1	0.43
2	84	16.0	2	0.26
3	5	15.5	3	0.37
4	36	25.0	5	0.51

a. From Whitney and Gearhart (1979).

airborne penta in many treated structures; one would expect higher penta levels in structures where treated wood is more extensively used, where ambient temperatures are higher, or where buildings are more tightly sealed.

c. Penta Residues in Human Urine and Serum

There are considerable data on penta residues in human urine. This information has been compiled and presented as Tables II.D-8 and II.D-9. It is clear that penta is prevalent in the urine of the general population. The results of Kutz et al. (1978) indicate that, among the pesticides detected in the Health and Nutritional Examination Survey II (HANES II) of the National Center for Health Statistics, penta was the most ubiquitous compound encountered; it was found in 85% of the urine samples analyzed. As would be expected, urinary penta levels among occupationally exposed persons (Table II.D-8) exceed the concentrations found in the general population (Table II.D-9).

As pointed out in the Agency's response to comment 17 (Section II.D.2.b), Lakings et al. (1980) found penta air levels of 0.20 and 0.38 ug/m^3 in a penta-treated log home. The levels of penta in the urine and serum of the residents of this home are presented in Table II.D-10.

TABLE II.D-8

Penta in Urine of Occupationally Exposed Populations

Population Description	Number of People	Number of Analyses	Penta Concentration in Urine (ppm) Min.	Max.	Mean
Commercial pest control operators[a]	130	210	0.003	35.7	1.8
No description[a]	121	121	0.003	38.6	0.47
Dip treaters[b]	11	136	---	---	2.6
Dip treaters[c]	---	---	0.12	9.68	2.83
Pressure treaters[b]	11	99	---	---	1.6
Pressure treaters[c]	---	---	0.17	5.57	1.24
Pressure treaters[d]	---	---	0.11	1.85	0.49
Pressure treatment plant employees[e]	6	---	0.043	0.76	0.164
Sapstain treaters (spray method)[c]	---	---	0.13	2.58	0.98
Carpenter[f]	1	4	---	---	0.024
Boat builder[f]	1	4	---	---	0.057
Sprayman[f]	1	4	---	---	0.133
Sprayman[f]	1	4	---	---	0.265

a. From Bevenue *et al.* (1967); location = Hawaii.
b. From Casarett *et al.* (1969); location = Hawaii.
c. From Morton and Freed (1973); location = Oregon.
d. From NIOSH (1975); location = Arkansas.
e. From Wyllie *et al.* (1975); location = Idaho.
f. From Cranmer and Freal (1970); location = Great Britain.

TABLE II.D-9

Penta in Urine of Nonocupationally Exposed Populations

Number of People	Number of Analyses	Penta Concentration in Urine (ppm) Min.	Max.	Mean
417(359)[a]	---	---	0.193	0.006
6[b]	24	0.002	0.011	---
117[c]	267	---	1.84	0.040
173[c]	173	0.003	0.57	0.044
60[d]	---	0.009	0.080	0.020
20[e]	20	0.010	0.050	---

a. From Kutz et al. (1978); location = continental U.S. Note only 359 people had measureable amounts of penta in their urine.
b. From Cranmer and Freal (1970); location = Great Britain.
c. From Bevenue et al. (1967); Location = Hawaii.
d. From Dougherty (1978); location = Florida.
e. From Akisada (1965); location = Japan.

TABLE II.D-10

Penta Residues in Residents of a Log Home[a]

Age	Sex	Levels (ppb)	Levels (ppb)[b]
2	Female	1,750	216
4	Female	1,680	51.2
9	Male	910	54.7
29	Female	580	50.8
34	Male	710	46.8

a. From Lakings et al. (1980).
b. Value represents unconjugated penta.

d. Revised Human Exposure Analysis for Specific Exposure Situations

In this section, realistic worst-case estimates of human exposure to penta are developed. For situations where actual measurements of penta are available, the highest experimental value observed was used in the exposure calulations when the totality of information on these situations indicates that this high figure was not an aberrant value.

i. Pressure Treatment: Usual Exposure

With the exception of two operations in a typical pressure treatment plant (i.e., opening of the pressure cylinder door and manually emptying penta bags), the maximum penta air levels reported by various investigators are consistent: 28 ug/m^3 (Arsenault, 1976), 20 ug/m^3 (Rapp, 1978), 15 ug/m^3 (Wyllie et al. 1975), and 8 ug/m^3 (NIOSH, 1977). The maximum penta air level reported by Arsenault (1976) of 28 ug/m^3 will be used to estimate the maximum inhalation exposure for a pressure-treatment worker (excluding those workers engaged in the two high exposure operations). Assuming 6 hours of light exercise and 2 hours of heavy exercise, this estimate is obtained:

$$\frac{(28\ \mathrm{ug/m^3}) \times (0.98\ \mathrm{m^3/hr}) \times (6\ \mathrm{hr})}{60\ \mathrm{kg}} +$$

$$\frac{(28\ \mathrm{ug/m^3}) \times (1.47\ \mathrm{m^3/hr}) \times (2\ \mathrm{hr})}{60\ \mathrm{kg}} = 4.1\ \mathrm{ug/kg/day}$$

During normal operations in a commercial pressure-treatment facility, there are few opportunities for employee dermal exposure to penta. Penta treatment formulations are generally mixed and applied in a closed system. An exception is the operation which formulates solutions from the bagged form of small penta pellets (also known as "prilled" penta). This particular exposure setting is dealt with in a subsequent section.

Most pressure treatment operations are highly mechanized and automated, and there is only rare, if any, manual handling of penta or the treated wood. Consequently, in view of the lack of data to the contrary, the Agency believes that the potential for dermal exposure in such facilities is considerably smaller than the potential for inhalation exposure. Hence a dermal exposure estimate for these workers will not be developed.

ii. Pressure Treatment: High Exposure

The air level data for penta in pressure-treatment plants indicate that opening of the pressure cylinder door and manually emptying bags of penta pose an unusually high risk of inhalation exposure. Although it is recognized that workers involved in such operations frequently wear respirators, this is not always the case. Thus, the exposure analysis for a worst-case situation assumes that a respirator is not worn. Also, Rapp (1978) noted that "respirators were usually not worn" during bag emptying operations in 28 wood treatment plants using penta.

The maximum penta air level reported by Arsenault (1976) when the cylinder door was opened was 1.0 mg/m^3. Rapp (1978) reported that airborne penta during opening of cylinders ranged from essentially 0 to as high as 150 mg/m^3. Of the 27 samples, 9 exceeded 1.5 mg/m^3, the OSHA TLV for short-term excursions of 15 minutes or less. It is recognized that exposure durations are likely to be short (less than 20 minutes) and that a single cylinder door would be opened, at most, twice during an 8-hour shift. Assuming that a female worker were exposed to penta at the maximum level reported by Rapp (1978) of 150 mg/m^3 for 1 hour at a light exercise level, the resulting exposure would be:

$$\frac{(150\ \text{mg/m}^3) \times (0.98\ \text{m}^3/\text{hr}) \times (1\ \text{hr})}{60\ \text{kg}} = 2.5\ \text{mg/kg/hr}$$

The above calculation is primarly illustrative, since the irritant properties of penta vapor would make unprotected exposure for long at such high levels unlikely. In the event that a respirator is not used, however, exposure of 2.5 mg/kg during that hour is a possibility.

A similar calculation using the maximum penta air level reported by Arsenault (1976) of 1.0 mg/m^3 yields this maximum predicted exposure:

$$\frac{(1.0 \text{ mg/m}^3) \times (0.98 \text{ m}^3\text{/hr}) \times (1 \text{ hr})}{60 \text{ kg}} = 16 \text{ ug/kg/hr}$$

This theoretical value seems a more likely possibility. Worker exposure for the remaining 7 hours of the work shift would probably not exceed the maximum level estimated previously for pressure-treatment workers in usual exposure situations (i.e., 4.1 ug/kg/8-hr day or 3.6 ug/kg/7-hr period). Thus a total daily exposure may be calculated as:

$$16 \text{ ug/kg} + 3.6 \text{ ug/kg} = 19.6 \text{ ug/kg/day}$$

Quantitative data on the potential dermal exposure of a worker engaged in the opening of a pressure cylinder door is not available. This deficiency, along with the lack of applicable data for similar situations with other pesticides which might be extrapolated to penta use situations, precludes the development of a dermal exposure estimate at the present time.

Manual emptying of penta bags also results in high penta air levels. The maximum penta air concentration level reported by NIOSH (1975) during this operation was 3.8 mg/m^3. Rapp (1978) reported that "...the airborne pentachlorophenol levels while dumping bags exceeded the established OSHA guidelines for short-term exposure (i.e., 1.5 mg/m^3 for 15 minutes) in 14 of the 49 samples. Two unusually high levels of 54 and 65 mg/m^3 were recorded. Respirators were usually not worn."

Many major wood treating plants, it is recognized, use 1) closed systems for the delivery of the prilled (granular) form of penta to mixing tanks, or 2) penta cast in block form. However, many other operations, especially ones in smaller firms, must empty the bags of prilled penta manually. The Agency estimates that workers may reasonably be expected to engage in bag emptying operations for a 4-hour period during an 8-hour work shift on a daily basis (Nicholas, 1980). As airborne penta can cause general upper respiratory distress, including painful nasal irritation and violent coughing and sneezing, individuals are not expected to inhale extremely high concentrations of vapor dust. Although concentrations greater than 1 mg/m^3 may cause this distress in unacclimated persons, concentrations as high as 2.4 mg/m^3 can be tolerated by those conditioned to exposure (American Industrial Hygiene Association, 1970). Since Rapp (1978) also indicates that respirators may not be worn, despite the presence of penta air levels exceeding OSHA guidelines, an estimate has been developed for the maximum predicted inhalation exposure for the workers. The estimate assumes 2 hours of light exercise in the mixing area, 2 hours of heavy exercise during the bag emptying operation, and 4 hours of light exercise in the plant's general grounds area:

$$\frac{(2.4\ \text{mg/m}^3)\ \text{x}\ (0.98\ \text{m}^3/\text{hr})\ \text{x}\ (2\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(2.4\ \text{mg/m}^3)\ \text{x}\ (1.47\ \text{m}^3/\text{hr})\ \text{x}\ (2\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(0.028\ \text{mg/m}^3)\ \text{x}\ (0.98\ \text{m}^3/\text{hr})\ \text{x}\ (4\ \text{hr})}{60\ \text{kg}} = 0.20\ \text{mg/kg/day}$$

The emptying of bagged penta by hand clearly has the potential for high dermal exposure. The Agency is not aware of any actual measurements of human dermal exposure during this operation. However, search of the technical literature revealed several exposure studies in which dermal exposure was measured during formulating and bagging operations with pesticide powders and dusts (Table II.D-11).

In the absence of more immediately relevent data on dermal exposure during emptying of bagged penta, the Agency believes that the data in Table II.D-11 can be used to make a rough estimate of potential dermal exposure. Since the penta formulation in question is pelleted and thus predominantly coarse in texture (although some fine material is present), the lower exposures calculated from the data in Table II.D-11 are probably more representative of the dermal exposure during this activity. As the workers involved in this operation are exposed to the dry, prilled form of penta, the Agency does not expect dermal absorption to exceed 1%. Thus, the Agency estimates a

TABLE II.D-11

Dermal Exposure During Pesticide Formulating[a]

	Dermal Exposure (mg/hr)		
	Mean	Range	Estimate for Penta[b]
Mixing and bagging of 4-5% carbaryl dust[c]:	73.9	0.8-1209	1478
Formulating 25% Guthion wettable powder[d]:	10.1	4.9-20.9	40
Formulating disulfoton as 0.5% dry mix fertilizer[e]:	2.0	0.1-10.5	400

a. Assumes workers were wearing short-sleeved shirts, no gloves or hats, and that covered areas of the body were protected from exposure.
b. Assumes worker is handling bags of pure penta
c. From Comer et al. (1975).
d. From Jegier (1964).
e. From Wolfe et al. (1978).

dermal exposure of 40 to 400 mg/hr x 1% absorption, or 0.4 to 4 mg/hr of emptying activity. Actual exposure could be either higher or lower, depending on the care taken during the operation.

As a worker may reasonably be expected to engage in bag emptying activites for a 4-hour period during an 8-hour work shift, the daily exposure is calculated as follows:

$$\frac{0.4 \text{ to } 4 \text{ mg/hr} \times 4 \text{ hr}}{60 \text{ kg}} = 0.027 \text{ to } 0.27 \text{ mg/kg/day}$$

iii. Dip/Flow Coating Treatment

Based on the penta air levels reported by the Environmental Health Sciences Center of Oregon State University for dip treatment operations (Morton and Freed, 1973), the maximum predicted inhalation exposure for dip treatment workers can be calculated.

The maximum penta air concentration found "in the area where a worker spends the majority of his time" was the same as that in the immediate area of the penta source (i.e., 63 ug/m^3). The resulting maximum inhalation exposure estimated for 6 hours at light exercise and 2 hours at heavy exercise is:

$$\frac{(63\ \text{ug/m}^3) \times (0.98\ \text{m}^3/\text{hr}) \times (6\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(63\ \text{ug/m}^3) \times (1.47\ \text{m}^3/\text{hr}) \times (2\ \text{hr})}{60\ \text{kg}} = 9.3\ \text{ug/kg/day}$$

There may be dermal exposure during dip or flow coat treatment, when the treatment process is not automated. No information is available on actual dermal contact in such operations, but it is reasonable to assume that workers' hands are likely to come in contact with the penta solution during manual operations. If gloves are not worn by the workers and enough of the 5% formulation to cover the surface area of both hands (i.e., 6 ml; see comment 8, Section II.D.2.b) reaches the skin of the worker, the estimated exposure is:

$$\frac{6\ \text{g [6 ml solution]} \times 0.05\ \text{[5\% concentration]} \times 0.1\ \text{[10\% absorption]}}{60\ \text{kg}}$$

$$= 0.5\ \text{mg/kg/day}$$

iv. Sapstain Control Treatment

Sodium penta is commonly used as a commercial sapstain control agent on freshly sawn lumber. Despite the low vapor pressure of sodium penta, some mist or vapor is generated during spray operations. In the worker exposure study conducted by the Oregon State University (Morton and Freed, 1973), air samples were taken at eleven companies which used sodium penta as a spray treatment for sapstain control. The maximum penta air concentration found in the area where a worker spends the majority of this time was 12 ug/m^3. The penta maximum air level found near the spray booth was reported as 69 ug/m^3. Although routine operations would not be expected to require all workers to spend a full 8-hour work shift in proximity of the spray operation, it is reasonable to assume that 8-hour exposures could occasionally occur for some workers. Hence, the 69 ug/m^3 air level will be used to derive an estimate of the maximum daily inhalation exposure for the sapstain worker. Assuming a female worker weighs 60 kg, 6 hours of light exercise, and 2 hours at heavy exercise, the resulting exposure is:

$$\frac{(69\ \text{ug/m}^3) \times (0.98\ \text{m}^3\text{/hr}) \times (6\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(69\ \text{ug/m}^3) \times (1.47\ \text{m}^3\text{/hr}) \times (2\ \text{hr})}{60\ \text{kg}} = 10.1\ \text{ug/kg/day}$$

Freshly sawn lumber is frequently treated with an aqueous solution (0.3% to 0.9%) of sodium penta to prevent the discoloration of the wood by molds, fungi, and bacteria. Following treatment (usually an automated process), lumber may be stacked or handled

manually. Assuming workers do not wear gloves, exposure patterns will likely resemble those of the dip/flow worker. Since a dilute solution is used, the exposure estimate for dip treaters must be corrected to reflect a reduction in predicted exposure. As sodium penta concentrations in sapstain solutions average 0.5% as compared with 5% for dip/flow solutions, the predicted dermal exposure is:

500 ug/kg/day x 0.1 (correction factor) = 50 ug/kg/day

v. Surface Spray Treatment

Plywood may be dipped or sprayed with a 2.5% solution of penta in an organic solvent. Since penta has a higher vapor pressure than its sodium salt, it may be predicted that ambient air levels during penta spraying would exceed the levels reported for sapstain operations. However, because there is little quantitative air level data for these operations, the exposure estimate will be developed by correcting the air levels recorded during spray sapstain operations to reflect the difference (2.5% vs. 0.5% penta concentration:

10 ug/kg/day x 5 (correction factor) = 50 ug/kg/day

Plywood may be either dipped or sprayed with a 2.5% solution of penta dissolved in an organic solvent. Although the actual spray operations involve automated processes, the Agency believes that some manual handling of the treated lumber is likely to occur after treatment. The resulting exposure is expected to resemble that incurred by the dip/flow worker. Since the penta solutions used for plywood spray operations is more dilute (2.5% vs 5.0%), the exposure estimates for dip/flow workers should be reduced by a factor of 2. Assuming that gloves are not worn by the workers, the predicted exposure is:

$$\frac{500 \text{ ug/kg/day}}{2 \text{ [correction factor]}} = 250 \text{ ug/kg/day}$$

Assuming that gloves are worn, a similar extrapolation from the data for dip treatment workers yields:

$$\frac{1.1 \text{ ug/kg/day}}{2} = 0.55 \text{ ug/kg/day}$$

vi. Occupational End-Use Activities

Carpenters, construction workers, lumber yard employees, and others may incur inhalation exposure to penta if they work with a significant amount of treated wood. This exposure will usually occur in outside or in well-ventilated indoor areas and, hence, the available penta air data derived from such settings will be used in the analysis. Wyllie et al. (1975) measured the penta air levels in the outside wood storage area of a small wood treatment plant in Idaho. The maximum penta air concentration reported by these investigators was 2.6 ug/m^3. If a 60-kg female employee were exposed to this air level at a light exercise level for 6 hours and a heavy exercise level for 2 hours, the resulting estimated exposure would be:

$$\frac{(2.6\ \text{ug/m}^3) \times (0.98\ \text{m}^3\text{/hr}) \times (6\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(2.6\ \text{ug/m}^3) \times (1.47\ \text{m}^3\text{/hr}) \times (2\ \text{hr})}{60\ \text{kg}} = 0.38\ \text{ug/kg/day}$$

It is probable that occupational exposure to treated wood may occasionally occur in poorly ventilated settings, such as storage sheds, railroad cars, warehouses. In such settings penta air concentrations are expected to be higher than the value cited above. The laboratory results of Thomspon *et al*. (1979), indicate that penta air levels as high as 40 ug/m^3 may occur when freshly treated wood is placed in a test cylinder at 25°C with a 2% air exchange rate per minute (see Table II.D-12). Using this penta air level to estimate a maximum predicted inhalation exposure estimate for workers occupationally exposed to treated wood in a poorly ventilated area gives:

$$\frac{(40\ \text{ug/m}^3) \times (0.98\ \text{m}^3\text{/hr}) \times (6\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(40\ \text{mg/m}^3) \times (1.47\ \text{m}^3\text{/hr}) \times (2\ \text{hr})}{60\ \text{kg}} = 5.9\ \text{ug/kg/day}$$

TABLE II.D-12

Vaporization of Penta from Pressure-Treated Wood[a]

Treating Solution	Penta Air Concentration (mg/m³) at: 25°C	30°C
Cellon®	0.028	0.053
MC	0.040	0.076
Oil	0.025	0.042

[a] From Thompson _et_ _al_. (1979).

It is likely that carpenters, construction workers, and others who handle penta-treated lumber will incur some dermal exposure, primarily through their hands if gloves are not worn. There are very limited data available on penta residues on treated wood surfaces (e.g., according to Koppers, utility poles have average penta surface residues of 3.9 ug/cm^2 7 weeks after treatment). This information, however, is not judged to be adequate to perform an assessment of human exposure from occupational contact with treated items. In addition, there is no information on the quantity of penta which may be transferred to human skin. Even so, it is reasonable to assume that if workers who handle penta-treated lumber wear gloves, their dermal exposure will be extremely low. Although a quantitative estimate is not possible, the exposure is expected to be considerably smaller than that predicted for workers handling the concentrated penta solutions (i.e., 1.1 ug/kg/day).

vii. Home and Farm Use

Human inhalation exposure resulting from the application of over-the-counter penta formulations may take two forms: inhalation during the application phase, and inhalation of vapors or particulates from the surface of the treated wood following application.

Most applications of these formulations by homeowners and farmers will take place outdoors during treatment of decks, fenceposts, wood siding and other exterior wood structures. These treatment operations are likely to be in well-ventilated areas.

If the formulations are applied by dip or brush application, penta air levels (during the application phase) would probably not exceed residue levels reported for the general (exterior) grounds of commercial wood treatment facilities. Wyllie et al. (1975) measured the penta air levels in the outside wood storage area of a small wood treatment plant in Idaho. The maximum penta air concentration reported by these investigators was 2.6 ug/m^3. If a 60-kg female were exposed to this air level for 6 hours of light exercise and 2 hours of heavy exercise, the estimated exposure is:

$$\frac{(2.6 \text{ ug/m}^3) \times (0.98 \text{ m}^3\text{/hr}) \times (6 \text{ hr})}{60 \text{ kg}} +$$

$$\frac{(2.6 \text{ ug/m}^3) \times (1.47 \text{ m}^3\text{/hr}) \times (2 \text{ hr})}{60 \text{ kg}} = 0.38 \text{ ug/kg/day}$$

The possibility that formulations containing penta may be sprayed by the user cannot be ignored, since the Pesticide Incidient Monitoring System (PIMS, 1978) has reports of human illness resulting from such spraying; in addition, not all labels caution against this application method. Available penta air measurement data are all derived from industrial settings where penta is applied in fixed-nozzle spray-booths. The Agency does not believe that a quantitative estimate of exposure for the home applicator can be derived from this information. The Agency does believe, however, that the potential human exposure arising from the spraying operation is likely to be much higher than the exposure arising from either the dipping or brushing operations. This is because typical spray operations with dilute penta wood preservative formulations involve spraying the sides of buildings using pesticide or paint sprayers. These operations can lead to considerable exposure from inhalation of suspended spray droplets or from spray deposition and splashing on the skin. Although no actual human exposure data for these operations are available, inhalation and dermal exposure has been measured during the use of hand-held pesticide sprayers in agricultural situations; extensive exposure, chiefly by the dermal route, was observed (Wolfe _et_ _al_., 1967).

When penta is applied to wood in a well-ventilated area, and the resulting treated structure remains outdoors, the human inhalation exposure will be "intermittent" (see comment 16, Section II.D.2.b). This is because homeowners or farmers would be expected to apply penta formulations to new or existing wood only for a short time once every few years. An exception might be the case of a farmer who applies penta over a single extended period every few years or who dips fenceposts intensively when replacing or installing a fence. In addition, treatment of the exterior siding of a residence is an operation that may reasonably take as long as a week to accomplish, assuming a homeowner does it several hours per day.

If a homeowner or farmer applies penta formulations to indoor wood (in barns, storage sheds, or residences) the inhalation exposure during application will also be intermittent. In such settings, penta air concentrations are expected to be higher than the values calculated for outdoor application. Thompson _et al_. (1979) measured penta air levels in a test chamber containing wood treated with penta in three different carriers: liquified petroleum gas (Cellon®), methylene chloride (MC), and oil. Their results (Table II.D-12) indicate that there may be penta air levels as high as 40 ug/m^3 when freshly treated wood is placed in a test cylinder at 25°C with a 2% air exchange rate per minute. This penta air level will be used to estimate the maximum predicted inhalation exposure for a homeowner or farmer applying penta indoors.

This value, derived from laboratory experiments, will be used rather than the maximum reported air level in pressure treatment plants. The value is more probable because ventilation in private structures is highly variable and depends on the nature of the structure (e.g., a barn of loose construction vs. a home). Recognizing that such applications may take as much as 4 hours, this following inhalation exposure estimate results:

$$\frac{(40\ \mathrm{ug/m^3}) \times (0.98\ \mathrm{m^3/hr}) \times (2\ \mathrm{hr})}{60\ \mathrm{kg}} \; +$$

$$\frac{(40\ \mathrm{ug/m^3}) \times (1.47\ \mathrm{m^3/hr}) \times (2\ \mathrm{hr})}{60\ \mathrm{kg}} = 3.3\ \mathrm{ug/kg/day}$$

No information is available on actual dermal contact during the application of these products by the general public. The degree of this contact will be wholly dependent on the care with which such products are handled by the individual appplicator. The Agency is not able to estimate precisely the frequency or the carelessness and misuse of these products. The scenarios which follow illustrate the degree of dermal exposure incurred by an individual who contacts various volumes of formulations:

a) 1 drop:

$$\frac{0.05\ \mathrm{g}\ [0.05\ \mathrm{ml\ solution}] \times 0.05\ [5\%\ \mathrm{conc.}] \times 0.1\ [\mathrm{dermal\ absorption}]}{60\ \mathrm{kg}}$$

$$= 4.2\ \mathrm{ug/kg/day}$$

b) 3 ml (a quantity sufficient to cover surface of one hand):

$$\frac{(3\ \mathrm{g}) \times (0.05) \times (0.1)}{60\ \mathrm{kg}} = 250\ \mathrm{ug/kg/day}$$

c) 6 ml (a quantity sufficient to cover surface of both hands):

$$\frac{(6\ \text{g}) \times (0.05) \times (0.1)}{60\ \text{kg}} = 500\ \text{ug/kg/day}$$

Inhalation exposure to penta vapors or particulates from the surface of the treated wood following application to exterior structures is expected to be extremely low.

If penta formulations are applied inside wooden structures (barns, storage sheds, homes, etc.) there will be exposure to vapor or particulates during application; exposure may be a significant ongoing process following the application phase as well.

The extent of human exposure resulting from such use depends on the type of structure (e.g., home vs. barn), the degree of ventilation, temperature, the length of time spent in the structure, and other variables. Since many labels for over-the-counter penta formulations do not warn against use in enclosed structures, including homes, use of such products in accordance with label instructions may result in the development of significant penta air levels with subsequent human inhalation exposure. Exposure times as high as 24 hours are reasonable for a maximum predicted exposure in such a situation.

Because recent trends in energy conservation have led to increasingly "airtight" homes, the likelihood of high penta air levels in homes where the chemical has been used is a significant concern. The Pesticide Incident Monitoring System (PIMS, 1978) has received numerous reports of human health effects following the application of penta inside homes. In several cases the description of the treated wood indicates that significant blooming of penta had occurred. Also, Thompson et al. (1979) observed blooming of penta in their experiments with Cellon®- and MC-treated wood, but not with oil-treated wood. In the event that blooming does occur, two factors are important. First, air currents from housecleaning activities such as dusting, could cause the small crystals to become airborne, thus generating a dust for respiratory exposure. It has not been possible to estimate the air penta concentration resulting from this process although there is a potential for high inhalation exposure. Second, as a result of blooming, crystalline penta is available for vaporization. Under these conditions, it is more likely that air penta levels in a closed system with a low air exchange will approach the theoretical vapor density equilibrium value of 2.2 mg/m^3. Even without blooming, however, significant penta air levels are expected.

Although the results of Thompson et al. (1979) cannot be directly extrapolated to situations in human structures because of the number of potentially confounding variables, they compare favorably with the results of Gebefugl et al. (1976) where concentrations as high as 0.16 mg/m^3 were detected in the air of a laboratory test area treated with paint containing penta.

In addition, the values reported by Thompson et al. fall within the range of air concentrations reported in commercial wood-treatment plants (Table II.D-6). In other words, the observed penta air levels in wood-treatment plants are very similar to the levels resulting from vaporization from treated wood.

It is interesting to note that eight months of weathering on an outside test fence reduced the air concentrations of penta (measured in the laboratory system) from Cellon®- and MC-treated samples to about 45 to 70%, respectively, of the original concentrations (Thompson et al., 1979). (The concentration of penta from the oil-treated wood was unaffected by weathering.) The results of these preliminary experiments are significant, since they suggset that penta-treated wood may serve as a source of airborne penta for an extended period of time. The recent report by Whitney and Gearhart (1979) lends further credence to this hypothesis and suggests that penta-treated wood may serve as a source of airborne penta for longer than 7 years.

The Agency believes that the application of penta formulations or use of penta-treated wood in homes may result in penta air levels which exceed levels detected in many commercial settings. Although human inhalation exposure during indoor application of penta formulations may be intermittent, exposure following application in enclosed spaces may occur for an indeterminate period of time. Hence, a worst-case approach would justifiably assume a continuous (24-hour), rather than an intermittent exposure. Using the maximum air concentration reported by the

Pesticide Incident Monitoring System (PIMS, 1978; see Section II.D.3.b.ii) and assuming 12 hours at rest, 10 hours of light exercise, and 2 hours of heavy exercise, a 60-kg woman might incur the following inhalation exposure:

$$\frac{(30\ \text{ug/m}^3) \times (0.27\ \text{m}^3/\text{hr}) \times (12\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(30\ \text{ug/m}^3) \times (0.98\ \text{m}^3/\text{hr}) \times (10\ \text{hr})}{60\ \text{kg}} +$$

$$\frac{(30\ \text{ug/m}^3) \times (1.47\ \text{m}^3/\text{hr}) \times (2\ \text{hr})}{60\ \text{kg}} = 8\ \text{ug/kg/day}$$

Since the available data do not suggest a significant difference between air levels from pressure-treated lumber and those achieved from brush application of over-the-counter formulations, the estimate also applies to potential exposure resulting from the use of pressure-treated lumber indoors.

The potential use of paints or sealants to eliminate penta volatilization from treated wood has not been adequately addressed in the literature. A preliminary experiment reported by Thompson _et_ _al_. (1979) indicates that paint may reduce, but not eliminate, penta volatilization from treated wood. Partial results from this experiment indicated that oil-base paint reduces penta vaporization to about 16% of uncoated sample values for Cellon®-treated boards and to 44% for oil-treated boards. Waterbase paints were less efficient in reducing vaporization. For MC-treated wood, for example, the values obtained for water-base paint were 59% of those for uncoated boards. These highly preliminary results suggest that paint may reduce penta vaporization rates from treated wood.

e. Summary of Revised Human Non-dietary Exposure Analysis

Table II.D-13 summarizes the revised exposure figures developed for penta in this Exposure Analysis.

Information available to the Agency indicates that commercial penta generally contains 15 and 100 ppm of HxCDD and HCB, respectively. In the absence of specific monitoring data for these two components of commercial penta, the Agency has adjusted the appropriate figures in Table II.D-13 in order to estimate human exposure to HxCDD and HCB. Tables II.D-14 and II.D-15 present these estimates.

f. Dietary Exposure

Residues of penta have been detected in several types of foodstuffs. The source of these residues is not clear. However, the current use of penta is about 50 million pounds per year, of which about 40 million pounds is used for wood preservation. As noted previously in this Exposure Analysis, the total amount of penta present in the environment in treated wood far exceeds this amount. Therefore, the use of penta as a

TABLE II.D-13

Summary of Estimated Human Exposure to Penta[a]

Site		Penta Exposure (ug/kg/day) Dermal	Inhalation[b]
Pressure Treatment			
Manual emptying of penta bags		27 to 270[c]	200
Opening cylinder door		d	20
General operations		e	4.1
Dip/Flow Treatment		500	9.3
Surface Spray Treatment		250	50
Sapstain Treatment (Dip)		50	f
Sapstain Treatment (Spray)		50	10
Occupational End Use			
Poorly-ventilated area		d	5.9
Well-ventilated area		d	0.38
Home and Farm Use			
During application:	indoors	4.2 to 500	3.3
	outdoors	4.2 to 500	0.38
After application:	indoors	d	8.0
	outdoors	d	g

a. Assumptions: 60-kg individual, 100% respiratory absorption and 10% dermal absorption.

b. Assumption: respirators are not worn.

c. Assumptions: workers are wearing short-sleeved shirts, they are not wearing hats or gloves, and covered areas of the body are protected from exposure.

d. No quantitative estimate is possible based on available data.

e. Exposure is considered negligible due to automated procedures and/or lack of significant residues.

f. Exposure is considered negligible due to low vapor pressure of sodium penta.

g. Exposure is considered negligible due to good ventilation.

TABLE II.D-14

Summary of Estimated Human Exposure to HxCDD[a]

Site	HxCDD Exposure[b] (ug/kg/day) Dermal	Inhalation[c]
Pressure Treatment		
Manual emptying of penta bags	0.00041 to 0.0041[d]	0.003
Opening cylinder door	e	0.0003
General operations	f	g
Dip/Flow Treatment	0.0033	g
Surface Spray Treatment	0.0038	0.00075
Sapstain Treatment (Dip)	0.00033	g
Sapstain Treatment (Spray)	0.00075	0.00015
Occupational End Use		
Poorly-ventilated area	e	g
Well-ventilated area	e	g
Home and Farm Use		
During application: indoors	0.000063 to 0.0076	g
outdoors	0.000063 to 0.0076	g
After application: indoors	e	g
outdoors	e	g

---

a. Assumptions: 60-kg individual, 100% respiratory absorption and 10% dermal absorption.
b. Assumption: commercial penta and sodium penta contain 15 ppm HxCDD.
c. Assumption: respirators are not worn.
d. Assumptions: workers are wearing short-sleeved shirts, they are not wearing hats or gloves, and covered areas of the body are protected from exposure.
e. No quantitative estimate is possible based on available data.
f. Exposure is considered negligible due to automated procedures and/or lack of significant residues.
g. Exposure is considered negligible due to low vapor pressure of HxCDD relative to that of penta.

TABLE II.D-15

Summary of Estimated Human Exposure to HCB[a]

	HCB Exposure[b] (ug/kg/day)	
Site	Dermal	Inhalation[c]
Pressure Treatment		
Manual emptying of penta bags	0.0027 to 0.027[d]	0.02
Opening cylinder door	e	0.002
General operations	f	0.00041
Dip/Flow Treatment	0.05	0.00093
Surface Spray Treatment	0.025	0.005
Sapstain Treatment (Dip)	0.005	0.000093
Sapstain Treatment (Spray)	0.005	0.001
Occupational End Use		
Poorly-ventilated area	e	0.00059
Well-ventilated area	e	0.000038
Home and Farm Use		
During application: indoors	0.00042 to 0.05	0.00033
outdoors	0.00042 to 0.05	0.000038
After application: indoors	e	0.0008
outdoors	e	g

---

a. Assumptions: 60-kg individual, 100% respiratory absorption and 10% dermal absorption.
b. Assumption: commercial penta and sodium penta contain 100 ppm HCB.c. Assumption: respirators are not worn.
d. Assumptions: workers are wearing short-sleeved shirts, they are not wearing hats or gloves, and covered areas of the body are protected from exposure.
e. No quantitative estimate is possible based on available data.
f. Exposure is considered negligible due to automated procedures and/or lack of significant residues.
g. Exposure is considered negligible due to good ventilation.

wood preservative
on barns, poultry houses, feed lot bins, food storage bins, etc., could lead to residues in food.

In a spot survey of selected food items, Dougherty and Piotrowska (1976) found penta residues in powdered milk, bread, soft drinks, candy bars, cereal, noodles, rice, sugar and wheat. As shown in Table II.D-16, the penta concentrations ranged from 1 ppb to 1 ppm. The presence of penta residues in all the grain and sugar products was attributed to the storage of these products in penta-treated wooden storage containers.

Penta residues in food have been found during total diet studies by the FDA (1979). In FY 1973, the number of composite samples that contained penta was 2 out of a total of 360 composite samples. In Fiscal Year (FY) 1975, the number of composite samples that contained penta increased to 13 out of a total of 240 composite samples. Penta residues were found in dairy products, grains and cereals, leafy vegetables, root vegetables, fruits, and sugar and its adjuncts. Reports of penta in dairy cattle in Michigan added to the concern about possible penta residues in the diet.

As part of its compliance Program, FDA (Martin 1979) has collected 198 of the projected 280 milk samples for FY 1979. Of the 198 samples analyzed (about 20%), 39 contained penta at or above 0.005 ppm. The highest value of penta reported, 0.231 ppm, was found in milk from New York State.

TABLE II.D-16

Spot Survey of Environmental Substrates for Penta

Substrate	Concentration of Penta (ppm)
Bond Paper	10.0
Textbook Paper	10.0
Powdered Milk	0.1
Soft Drink (Diet)	0.001
Soft Drink	0.001
City Water	0.0001
Bread	1.0
Candy Bar (2 brands)	0.1
Cereal	0.1
Noodles	0.1
Rice	0.01
Sugar	0.1
Wheat	0.1

a. Derived from Dougherty and Piotrowska, 1976.

From January through September, 1978, the U.S. Department of Agriculture collected liver samples from beef, swine, and poultry throughout the United States. Table II.D-17 summarizes the percentages of positive findings and concentration ranges within each species. This survey, although preliminary, showed that in all instances the percentage of positive findings was higher than 86%.

The Agency's National Surface Water Monitoring Program for FY 1978 analyzed a total of 600 water samples taken from 153 sampling locations in 43 states. About 5% of all the water samples were positive for penta. The overall average was about 0.13 ppb. Furthermore, Zitko *et al*. (1974) surveyed the penta levels in the aquatic fauna of New Brunswick, Canada. Values in fish ranged from 0.082 ug/kg in codfish to 3.99 ug/kg in white flounder.

Although some of the studies reviewed in the preceding pages were preliminary in nature and sometimes inconclusive, they suggest that penta is a ubiquitous environmental contaminant. The contribution of specific uses of penta to the overall environmental burden is not known.

TABLE II.D-17

Penta Residues in Liver Samples[a]

Species	Number of Samples	Number of States	Percent Positive Findings	Range (ppm)
Cow	108	32	86	0.001-0.70
Heifers	60	18	92	0.001-0.50
Market Hogs	102	24	99	0.001-2.00
Sows	45	12	100	0.001-1.50
Young Chicken	95	20	98	0.001-0.15
Mature Turkeys	83	15	94	0.001-0.70
Breeder Turkeys	26	11	92	0.001-0.04

a. From USDA (1978; unpublished).

4. Pentachlorophenol's Potential Oncogenicity

a. Introduction

The Agency reviewed, in PD-1, three studies concerning penta's possible oncogenicity. Innes et al. (1969) administered (by gavage) 46.4 mg/kg penta to mice on days 7 through 28 of age, followed by 130 ppm (17 mg/kg/day) in the diet for 17 months. They reported that this regimen caused no significant increase in tumor incidence in the test animals when compared with controls.

In 1976, Schwetz et al. reported that 1, 3, 10, and 30 mg/kg/day of purified penta in the diet for 2 years did not increase tumor incidence over control animals.

Boutwell and Bosch (1959) applied 0.3% dimethylbenzanthracene in benzene as an initiator to the shaved backs of mice. As a promoter, a solution of 20% penta in benzene was applied similarly twice weekly for 15 weeks. The average number of papillomas per survivor was 0.04 in the test group, slightly less than the 0.07 observed in the controls. The number of survivors with papillomas was 4% in the test group and 7% in the control group.

These papers were reviewed by the Agency's Carcinogen Assessment Group and were found to be negative with respect to oncogenic effects of penta. Since publication of PD-1, however, several other studies pertinent to the oncogenic potential of commercial penta and its contaminants have been brought to the Agency's attention. These are discussed below.

b. Hexachlorodibenzo-p-dioxin

In March 1980, the Agency received from the National Cancer Institute the final draft reports of two bioassay studies dealing with the possible carcinogencity of two isomers of HxCDD. The results of one study, on the dermal application of HxCDD to mice, were negative. The second study involved oral administration of HxCDD to both rats and mice. The doses ranged from 1.25 mg/kg/week to 10 mg/kg/week. Under the conditions of this study, HxCDD increased the incidence of benign and neoplastic liver tumors in mice of both sexes and in female rats. (See Section II.D.5.b for quantitative risk assessment.)

c. Hexachlorobenzene

Testimony before the Environmental Health Advisory Committee of the Agency's Science Advisory Board (SAB) revealed that HCB was present in commercial preparations of penta. A subsequent search of the scientific literature found two studies (Cabral *et al.*, 1977; 1979) demonstrating that HCB is oncogenic.

In the 1977 study, six-week-old Syrian golden hamsters were fed a diet containing 50, 100 or 200 ppm HCB (99.5% pure) *ad libitum* for life. Although no hepatomas were observed in the control group, the incidence of hepatomas in the treated hamsters increased from 47% in the 50 ppm female group to 85% in the 200 ppm female group. Similar results were found in the male hamsters.

Cabral _et_ _al_. (1979) studied the effects of the same dietary levels in Swiss mice. Again, the treated groups (both male and female) had significantly greater incidences of hepatomas when compared to the controls. (See Section II.D.5.b for the quantitative risk assessment.)

5. Quantitative and Qualitative Risk Assessments

a. Fetotoxic, Teratogenic, and Reproductive Effects

i. Introduction

Since the publication of PD-1, new information has been found on the fetotoxic and reproductive effects of penta and its contaminants. These new data are described below in Section II.D.5.a.ii. Then, in Section II.D.5.a.iii, these new data will be combined with the toxicological data discussed earlier and with other data on penta exposure to assess quantitatively the fetotoxic reproductive risk of penta and its contaminants to humans.

ii. Additional Data Reviews

One-Generation Rat Reproduction Study of Penta

Schwetz et al. (1978), in a dietary study, randomly separated 7-week old Sprague-Dawley (Spartan substrain) SPF-derived rats into test groups and allowed them to acclimatize for 1 week. There were 10 male and 20 female rats in each treatment group and in the control group. The investigators mixed penta (dissolved in anisole) with Purina Lab Chow to make a 1% premix, from which test diets were prepared weekly and fed to the treatment groups. (Table II.D-18 shows the composition of the penta used in this study.) When adjusted weekly for changing

TABLE II.D-18

Composition of Dowicide® EC-7[a]

Component	Amount
Phenols	Percent
Trichlorophenol	<0.1
Tetrachlorophenol	10.4 ± 0.2
Pentachlorophenol	90.4 ± 1.0
Dibenzo-p-dioxins	ppm
2,3,7,8-Tetrachloro-	<0.05
Hexachloro-	1.0 ± 0.1
Heptachloro-	6.5 ± 1.0
Octachloro-	15.0 ± 3.0
Dibenzofurans	
Hexachloro-	3.4 ± 0.4
Heptachloro-	1.8 ± 0.3
Octachloro-	<1

a. From Schwetz *et al*. (1978).

food consumption and body weights, this diet resulted in doses of 3 and 30 mg kg/day penta. All rats were observed daily. Body weights were recorded on days 0, 29, and 62 of the study, as well as 21 days after parturition. After 62 days on the test diet, each male was placed with two females from the same treatment regimen for 15 days, which is three estrus cycles in normal female rats. After the 15-day period, the males were returned to individual cages and given the appropriate dose-level diet. Females were maintained in individual cages with ground corn-cob litter for nesting. Treatment diets for females continued throughout parturition and for 21 days following parturition. After 21 days of lactation, the females and their young were killed and necropsies were performed. One male and one female of each litter were prepared for skeletal examination. The adult male rats were sacrificed and examined at the end of the study.

Indices of reproduction were evaluated by the Fisher exact probability test, and body weights were analyzed by Dunnett's test. The level of significance in all cases was $P<0.05$.

Statistically significant depression of parental body-weight gain was reported at the 30 mg/kg/day dose for males at all measurement periods, and for females at the last (62nd day) period. At the 3 mg/kg/day dose, there was an apparent trend toward decreased weights in both sexes at all periods reported. This trend exists in the absence of significant depression at any specific period.

At the 30 mg/kg/day dose, the neonatal weights of both sexes compared to controls were significantly lower at all four periods reported. The data for the 3 mg/kg/day dosage shows a trend toward decreased weight (consistent with the high dosage) which continues as the animals age. However, this weight decrease at 3 mg/kg/day is not statistically significant at any individual day.

Measured either as absolute weights or as liver-to-body weight ratios, changes in maternal liver weight at either dosage were not significant compared to controls. Daily inspection revealed no treatment-related effects on demeanor or physical appearance in either adults or young.

Among the reproduction indices reported, neither the fertility index nor the 24-hour survival index was significantly different from controls at either dose. By Dunnett's test four indices at 30 mg/kg/day were significantly less than control: gestation survival, and 7-day, 14-day, and 21-day survival. Average litter sizes were significantly less than controls on days 7, 14, and 21 at the 30 mg/kg/day dose. Gestation-period length showed no significant treatment-related effect.

At this 30 mg/kg/day dose there was also a general trend toward increased frequency of abnormalities in all parameters reported. Statistically significant increases at this dose were reported for lumbar spurs and for vertebrae with split centrum. At the 3 mg/kg/day level there was neither a trend toward increased abnormalities nor any statistically significant increases in any of the parameters reported.

Schwetz et al. (1978) is adequate to establish 3 mg/kg/day as the fetotoxicity NOEL for the penta analyzed. The test material (see Table II.D-18) was reported to contain 10-fold less hexachloro-, 30-fold less heptachloro-, 200-fold less octachlorodibenzo-p-dioxin, and 6- to 300-fold less of the dibenzofurans than at least one of the currently manufactured technical pentas.

Eight-Month Rat Feeding Study of Penta

Goldstein et al. (1977) fed female rats 20, 100, or 500 ppm of either technical or purified penta for 8 months. The technical penta used for this study was reported to contain only slightly less HxCDD and hexachlorodibenzofuran than the levels reported for a currently manufactured commercial penta.

Dosing at 20 ppm (about 1.5 mg/kg/day as interpolated from food consumption data) resulted in a 15-fold increase over the control in the activity of aryl hydrocarbon hydroxylase (AHH). Purified penta, on the other hand, had no significant effect on AHH induction at any dose tested. Glucuronyl transferase activity was also significantly elevated at the 20 ppm treatment level by the technical penta used in this study. The Agency is not aware of a meaningful toxic state which can be associated, in this case, with the reported levels of enzyme induction or elevation. However, elevated AHH activity has been used as a "biochemical correlate" (Goldstein, 1980) for the presence in biological samples of some of the nonphenolic contaminants of technical penta. At a level of 20 ppm neither technical nor purified penta in this study affected the excretion of urinary porphyrins or their precursors. The liver-to-body weight ratio was not affected significantly at 20 ppm by either grade of penta.

Chronic and Subchronic Feeding Studies of Penta

Additional assessment of parental chronic toxicity allows comparison of penta dose levels causing fetotoxicity with those doses causing significant effects in adult animals. A 2-year chronic feeding and oncogenicity study in rats (Schwetz *et al*., 1978) shows a NOEL of 3 mg/kg/day for body-weight change and food consumption of the adults. In addition, this study was unable to demonstrate a significant increase of either benign or malignant tumors in either sex.

The 8-month rat (male and female) feeding study of Kimbrough and Linder (1978), using the technical penta of the Goldstein study (Goldstein *et al*., 1977), showed only "mild" histological alterations (unspecified) in the liver at the 20 ppm dietary concentration.

The results of 90-day feeding studies are also useful for comparison with fetotoxic effects, which may occur with relatively short exposure duration. In a 90-day rat feeding study, Kociba *et al*. (1973) used doses of 1, 3, 10, and 30 mg/kg/day. Several of the adult body-weight gains were significantly different from controls: males were higher, females were lower. A comparison of the pooled dose means with controls, however, failed to show a treatment effect. The testes-to-body-weight ratios were lower than controls at all doses and significantly lower at 10 and 1 mg/kg/day. Also, there was no clearly established NOEL for serum glutamic pyruvic transaminase or alkaline phosphatase elevations.

The 90-day rat feeding study of Knudsen _et al_. (1974), done with an inadequately described technical penta, showed significantly elevated alkaline phosphatase levels in females at 1.1 mg/kg/day. Liver and kidney weights appeared to show a dose-related increasing trend in both sexes. The liver weight increase in females was significant at 2.5 and 10 mg/kg/day. Liver histopathology, specifically centrilobular vacuolization, was present in both sexes at 10 mg/kg/day. At 2.5 mg/kg/day, this effect was marginally elevated in females but absent in males.

A third 90-day rat feeding study (Johnson _et al_., 1973) also was done with an incompletely described technical penta. The NOEL was 3 mg/kg/day, based on increased liver weight at higher doses.

Fetotoxic, Teratogenic, and Reproductive Effects of HCB

Courtney et al. (1976) reported a teratogenic effect caused by HCB in mice. Oral administration to CD-1 mice on days 7 to 16 of gestation showed that HCB at 100 mg/kg/day produced significantly elevated maternal liver-to-body weight ratios and decreased fetal body weights. The number of abnormal fetuses per litter increased significantly. In one of the litters the abnormalities included some cleft palates.

Khera (1974) reported fetotoxic effects, which were limited to dose-related sternal defects at doses of 40 mg/kg (days 6 to 21 of gestation) and to a significantly increased incidence of uni- or bilateral fourteenth ribs. This latter effect was dose- and duration-dependent and commenced at the lower dose (10 mg/kg/day) during either days 6 to 16 or days 10 to 13 of gestation. There were no HCB-related effects on external morphology. Khera did not observe visceral deformities and histological examination was negative. The parameters of a concurrent dominant lethal assay were all within the control range. There was a NOEL of 60 mg/kg/day for maternal toxicity (weight loss and convulsions) when HCB was administered on gestation days 6-21 or for shorter periods.

Simon et al. (1979) also observed that HCB, when administered at either 70 or 221 mg/kg/day for 5 days, would not induce dominant-lethal mutations in the rat. At these two doses, however, HCB showed a dose-dependent decrease in the number of females inseminated and impregnated.

Grant _et_ _al_. (1977), in a four-generation rat reproduction study, found that pregnancy, viability, lactation indices, neonatal weight gain, and relative liver weight all had a NOEL of 1.0 mg/kg/day dietary HCB. At a 4-fold higher dose, several of the maternal animals died. No gross abnormalities were observed in the young rats.

In several mammalian species penta is one of the metabolites of HCB. Koss _et_ _al_. (1978) dosed female rats with HCB on alternate days at 50 mg/kg. These researchers found a blood ratio of penta (as a metabolite of HCB) to HCB of about 1:10 at steady-state. The mean blood concentration of HCB in the general population is reported to be less than 1 ppb (Strassman-Sundy, 1980).

iii. Quantitative Human Risk Assessment of Fetotoxic Effects

Margins of Safety for Population Sub-Groups

For the fetotoxicity risk assessment of penta for occupational sub-groups, the Agency has calculated individual values of the Margin of Safety (MOS). The MOS value is the ratio of the NOEL in animal experiments to the appropriate sub-group exposure value. PD-1 stated that the study of Schwetz _et_ _al_. (1974) indicates the fetotoxic and teratogenic properties of penta. The Agency continues to maintain that Schwetz _et_ _al_. (1974), a study which has not been invalidated, shows that penta causes several fetotoxic responses in rats. The Agency notes that the incidence of delayed skull ossification was significantly increased at 5 mg/kg/day (purified-grade penta), the lowest dose tested. Thus, this risk assessment uses the NOEL of 3 mg/kg/day as shown in the one-generation study of Schwetz *et al*. (1978). For penta and two of its major contaminants the following NOEL values are used for MOS calculation:

penta:	3 mg/kg/day (Schwetz *et al*., 1978
HxCDD:	0.1 ug/kg/day (Schwetz *et al*., 1973)
HCB:	1.0 mg/kg/day (Grant *et al*., 1977)

The calculated MOS values, based on the exposure figures presented in Tables II.D-13 to II.D-15, are listed in Tables II.D-19 to II.D-21.

b. Oncogenicity

As discussed in Section II.D.4, there is reason to believe that exposure to technical penta poses a finite oncogenic risk. The quantitative assessment of that risk follows.

The experimental data used as the basis of this risk assessment is taken from the National Cancer Institute (1980) study in which Osborne-Mendel Rats and B6C3F1 mice were administered either a vehicle control (3 groups of 25 per sex per species) or HxCDD (50 animals per sex per species for each dosage level).

TABLE II.D-19

Margins of Safety for Fetotoxic Effects Based on Estimates of Human Exposure to Penta

Site		Total Penta Exposure (ug/kg/day)[a]	Margin of Safety[b]
Pressure Treatment			
Manual emptying of penta bags		227 to 470	6.4 to 13
Opening cylinder door		20[c]	150
General operations		4.1	730
Dip/Flow Treatment		510	5.9
Surface Spray Treatment		300	10
Sapstain Treatment (Dip)		51	59
Sapstain Treatment (Spray)		60	50
Occupational End Use			
Poorly-ventilated area		5.9[c]	510
Well-ventilated area		0.38[c]	7,900
Home and Farm Use			
During application:	indoors	7.5 to 500	6 to 400
	outdoors	4.6 to 500	6 to 650
After application:	indoors	8[c]	380
	outdoors	d	---

a. Sum of dermal and inhalation exposure estimates from Table 9.
b. NOEL = 3 mg/kg/day = 3,000 ug/kg/day.
c. Due to lack of data, this estimate does not include dermal exposure.
d. No estimate possible due to lack of dermal exposure data.

TABLE II.D-20

Margins of Safety for Fetotoxic Effects Based on Estimates of Human Exposure to HxCDD

Site		Total HxCDD Exposure (ug/kg/day)[a]	Margin of Safety[b]
Pressure Treatment			
Manual emptying of penta bags		0.0034 to 0.0071	14 to 29
Opening cylinder door		0.0003[c]	330
General operations		d	---
Dip/Flow Treatment		0.0033	30
Surface Spray Treatment		0.0046	22
Sapsatin Treatment (Dip)		0.00033	300
Sapstain Treatment (Spray)		0.0009	110
Occupational End Use			
Poorly-ventilated area		e	---
Well-ventilated area		e	---
Home and Farm Use			
During application:	indoors	0.000063 to 0.0076	13 to 1,600
	outdoors	0.000063 to 0.0076	13 to 1,600
After application:	indoors	e	---
	outdoors	e	---

---

a. Sum of dermal and inhalation exposure estimates from Table 10.
b. NOEL = 0.1 ug/kg/day.
c. Due to lack of data, this estimate does not include dermal exposure.
d. Exposure is considered negligible due to automated procedures, lack of significant residues, and low vapor pressure of HxCDD.
e. No estimate possible due to lack of dermal exposure data.

TABLE II.D-21

Margins of Safety for Fetotoxic/Reproductive Effects Based on Estimates of Human Exposure to HCB

Site		Total HCB Exposure (ug/kg/day)[a]	Margin of Safety[b]
Pressure Treatment			
Manual emptying of penta bags		0.023 to 0.047	>10,000
Opening cylinder door		0.002[c]	>10,000
General operations		0.00041	>10,000
Dip/Flow Treatment		0.051	>10,000
Surface Spray Treatment		0.03	>10,000
Sapstain Treatment (Dip)		0.0051	>10,000
Sapstain Treatment (Spray)		0.006	>10,000
Occupational End Use			
Poorly-ventilated area		0.00059[c]	>10,000
Well-ventilated area		0.000038[c]	>10,000
Home and Farm Use			
During application:	indoors	0.00075 to 0.05	>10,000
	outdoors	0.00046 to 0.05	>10,000
After application:	indoors	0.0008[c]	>10,000
	outdoors	d	---

a. Sum of dermal and inhalation exposure estimates from Table 9.
b. NOEL = 1 mg/kg/day = 1,000 ug/kg/day.
c. Due to lack of data, this estimate does not include dermal exposure.
d. No estimate possible due to lack of dermal exposure data.

Fifty additional animals per sex per species were used as untreated controls.

The study doses were administered by gavage twice a week for 104 weeks. (The dosages shown in Table II.D-22 are the total weekly dose per animal.) Three or 4 weeks after the dosing period the surviving animals were sacrificed and necropsied. Moribund animals were sacrificed and necropsied throughout the study; thus, histopathology results are available for more than 90 percent of the animals of each study group.

The data shown in Table II.D-22 indicate the number of animals per sex per species with liver tissue examined (No.) and the number of animals with liver neoplastic nodules or adenoma and/or hepatocarcinoma (R). These data suggest a dose-related increase in the incidence of this condition over the control frequency in each sex and in each species. The effect appears to be better defined in the rat, and the female rats seem to be the most sensitive group. The response of the male mice closely approximates that of the female rats. Evaluating the statistical significance of the dose-response relationship observed in each sex and species, the NCI report states that there is a statistically significant dose-related trend for this diagnosis at P = 0.001 to 0.003 in all four sex and species groups, as calculated by the Cochran-Armitage Test (Armitage, 1973). When the Bonferroni (Dunn, 1961; Miller, 1966) inequality is used to adjust the nominal P = 0.05 level of test by dividing by the number of doses, the reference value is P = 0.017. This results in a finding of statistical significance

TABLE II.D-22

Incidence of Observed Neoplastic Nodules and/or Carcinoma[a] Observed and Risk Estimates Completed

Dose of HxCDD (ug/kg/wk)	Osborne-Mendel Rat				B6C3F1 Mice			
	Male		Female		Male		Female	
	No.[b]	R[c]	No.	R	No.	R	No.	R
0.00	74	0	75	5	73	15	73	3
1.25	49	0	50	10	50	14	0	—
2.50	50	1	50	12	49	14	48	4
5.00	48	4	50	30	48	24	47	6
10.00	0	—	0	—	0	—	47	10

---

a. Data from NCI, 1980.
b. Number of animals in treatment group.
c. Number of neoplastic nodules and/or hepatocellular carcinomas observed.

for the high and mid-dose female rats and high-dose male and female mice. The rate in the high-dose male rats is not considered to be statistically significant because $P = 0.022$ is larger than 0.017.

As the female rat and male mouse have similar high levels of statistically significant response, a quantitative assessment of risk has been performed for each of these two groups. The slopes calculated from the data in Table II.D-14, using the One-Hit model are 0.1233 for rats and 0.047 for mice where the dose is given in ug/kg/wk. The correction factors for conversion to the appropriate slopes in humans are 7 fold for rats and 12 fold for mice. These factors are derived from toxicity studies of anticancer agents reported by Freireich *et al*. (1966).

Thus, the appropriate slopes when the dose is in ug/kg/wk in humans are:

$7 \times 0.1233 = 0.863$ from the rat data

and

$12 \times 0.047 = 0.564$ from the mouse data

These are transformed to the equivalent slopes for dosage in ug/kg/day by multiplication by 7:

slope = 7 x 0.863 = 6.04 from the rat data

and

7 x 0.564 = 3.95 from the mouse data

to compute the risk to humans based upon a dose in ug/kg/day.

The slope derived from the rat data is used in this analysis to estimate risk to humans, as the rat appears to be more sensitive than the mouse. The total occupational exposures (sum of dermal and inhalation exposures in Table II.D-14) are adjusted to average daily exposure for a lifetime by multiplying the total exposure by 5/7 (fraction of week exposed, assuming a 5-day work week) and by 1/2 (assuming a worker is exposed for 1/2 a lifetime). [Note that all exposure figures have been derived using a woman's average weight (60 kg) and breathing rates. When these figures are derived using the average weight (70 kg) and breathing rates of a man, the difference in exposure figures are insignificant.] This average daily exposure for a lifetime is then multiplied by the slopes given above (6.04 and 3.95) to obtain the estimates of cancer risk in an individual's lifetime. These estimates are presented in Table II.D-23.

Technical penta also contains hexachlorobenzene (HCB), another known oncogen. In this document, however, the quantitative oncogenic risk for penta is based on the HxCDD contaminant alone because the HCB slope is so much lower than the HxCDD slope that including the HCB-related risk would have only a negligible effect on the total oncogenic risk.

TABLE II.D-23

Individual Oncogenicity Risk Estimated Due to HxCDD Exposure

Site	Estimated Exposure[a] (in ug/kg/day x 10^3)	Estimate of Risk[b]
Pressure Treatment Manual emptying of bags	1.2 to 2.5	7.3×10^{-3} to 1.5×10^{-2}
Opening cylinder door	0.11	6.6×10^{-4}
General operations	c	c
Dip/Flow Treatment	1.2	7.2×10^{-3}
Surface Spray Treatment	1.6	9.7×10^{-3}
Sapstain Treatment (Dip)	0.12	7.2×10^{-4}
Sapstain Treatment (Spray)	0.32	1.9×10^{-3}
Home and Farm Use During application: indoors	0.00017 to 0.021	1.0×10^{-6} to 1.3×10^{-4}
outdoors	0.00017 to 0.21	1.0×10^{-6} to 1.3×10^{-4}
After application:		
indoors	d	d
outdoors	d	d

a. Average daily exposure for lifetime.
b. Based on slope of 6 derived from results of NCI (1980) for female rat.
c. Exposure is considered negligible due to low vapor pressure of HxCDD.
d. No estimate possible due to lack of exposure data.

The slope for HCB obtained is 0.025, based on the dosing in ppm in the diet of male hamsters (Cabral _et al._, 1977). This slope was computed using the One-Hit model, the same model that was used in computing the slopes for HxCDD shown above. The HCB slope expressed in terms of ug/kg/day for humans is 0.0027. Even considering the greater amount of HCB for most cases than HxCDD in technical penta (100 ppm versus 15 ppm), the oncogenic risk posed by HCB is negligible when compared with that of HxCDD.

There are a few situations where exposure to HxCDD has been determined to be negligible (see Table II.D-14). The greatest HCB exposure under these circumstances is 0.00059 ug/kg/day for occupational end use, poorly ventilated area (see Table II.D.15). Adjusting this figure to an average daily exposure for a lifetime yields an estimated exposure of 0.00021. Multiplying this estimate by the slope for HCB results in an estimated lifetime cancer risk of about 6×10^{-7}. Consequently, due to the very small influence of HCB on the total oncogenic risk, the oncogenic risk from technical penta is based entirely on exposure to HxCDD.

E. Alternatives

1. Introduction

This section provides a brief discussion of the toxicological characteristics of the available alternatives to the RPAR wood preservatives. The objective of this section is to present an overview of toxicology data derived from literature reviews of representative scientific articles. It is not possible to provide a comprehensive, validated data review since a preliminary survey of the data base indicates extensive data gaps. Since these chemicals may be substituted for one or more uses of the RPAR chemicals, the Agency's primary concern focuses on the potential of the alternatives for adverse chronic effects. Acute toxicology data is provided when chronic data is lacking.

The chemicals considered possible alternatives are listed below (Cummings, 1980). The suitability of these chemicals is discussed on a use-by-use basis in the following Benefit Analysis (Part III) of this document.

Acid Copper Chromate (ACC)
Chromated Zinc Chloride (CZC)
Bis(tributyltin) oxide (TBTO)
Copper-8-Quinolinolate (Cu-8)
Copper Naphthenate
Zinc Naphthenate

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Chromated Zinc Chloride (CZC)

Trichlorophenol (TCP)

Tetrachlorophenol (Tetra)

2. Acid Copper Chromate (ACC) and Chromated Zinc Chloride (CZC) as Chromium.

The Agency's data base does not contain toxicology data specific to CZC and ACC. However, because chromium is a common component of both CZC and ACC, some discussion of chromium is applicable inlight of the absence of more relevant data.

Chromium is a suspected oncogenic and mutagen. Chromates, particularly calcium chromate, have been shown to be mutagenic by multitest evidence (Venitt *et al*, 1974; Nishioka, 1975; and Fradkin *et al*., 1975). Additionally, epidemologic studies indicate chromate is a carcinogen with bronchogenic carcinoma as the principal lesion (Doull *et al*., 1980). Nettlesheim *et al*., (1971) demonstrated the induction of adenocarcinomas and adenomas in the bronchial tree of mice by exposing them to calcium chromate dust. Laskin *et al*., (1970) also produced carcinoma in mice with calcium chromate by intrabronchial implant.

The Agency recognizes that one cannot extrapolate from data based on chromium to determine the toxicological effects of CZC and ACC. However, the Agency does conclude that CZC and

ACC warrant further toxicology testing due to the potential for adverse chronic effects.

3. Bis(tributyltin) oxide (TBTO)

a. Acute Toxicology

Tests involving male rats demonstrated acute oral LD_{50}'s of 194 mg/kg and 148 mg/kg when administered technical TBTO at 10% v/v in an aqueous suspension and in corn oil, respectively (Elsea, et al., 1958).

The rabbit dermal LD_{50} for technical TBTO was shown to be 11.7 gm/kg. (Elsea, et al., 1958).

Test results showed TBTO to be a skin sensitizer in guinea pigs when administered as a 0.1% v/v concentration in sesame oil. (Elsea, 1956).

In a primary skin irritation study, rabbits received a 24 hour exposure to pig-skin impregnated with TBTO at concentrations ranging from 31.25 to 1000 ug per/square inch. At concentrations of 0.5 mg/per square inch or less, TBTO was not a primary irritant, but was considered to be corrosive at 1.0 mg/per square inch. (International Research and Development Corp., 1966).

Extreme eye irritation and corneal damage resulted when 6 New Zealand strain rabbits were treated with 100 mg of TBTO (Hine Laboratories, 1976).

When rats received a one hour mist inhalation exposure to varying concentrations of TBTO (0.2-2.0 mg/liter), the acute inhalation LC_{50} was determined to be 0.48 mg/liter. (Food and Drug Research Laboratories, 1976).

The above studies indicate TBTO's potential for acute adverse effects. At the dosages tested in the oral and inhalation studies TBTO may not be considered acceptable for domestic use situations unless classified for restricted use. The eye irritation study also suggests that the Agency would consider only a restricted use classification for all domestic and non-domestic uses of TBTO.

b. Chronic Toxicology

Data are unavailable in the Agency's files to determine long-term effects of TBTO.

4. Copper-8-Quinolinolate (Cu-8)

a. Acute Toxicology

When Sprague-Dawley rats were orally dosed with 90% Cu-8 (as a 20% suspension), LD_{50} values for male rats were 4.7 gm/kg; the LD_{50} for female rats was 3.9 gm/kg. (Ezumi *et al*., 1971).

The rabbit acute dermal LD_{50} was 2.0 gm/kg for a 96% Cu-8 powder (Mouser, 1973a). Using the same formulation, rabbits were observed to have slight eye irritation after seven days of observation (Mouser, 1973b).

Acute inhalation studies utilizing 60 Sprague-Dawley rats, divided into groups, received 4 hours of exposure to respirable, technical Cu-8 dust (0.13, 0.69, 0.95, 1.21, 1.27 mg/liter). After 14 days of observation the inhalation LC_{50} was determined to be 0.82 mg/liter. (Berczy, *et al*., 1975).

It is difficult to relate the above data to actual risk potential due to the high dosage rates used in testing. However, it is demonstrated that technical and near technical grade (90.0% and above) Cu-8 is acutely toxic, particularly by the inhalation route. Dermal exposure appears to be less hazardous, but may also prove to be unacceptable for general use at the dosage tested.

b. Chronic Toxicity

Ames tests conducted with 4 tester strains of Salmonella typhimurium showed some evidence of mutagenic potential, specifically of the frame-shift type. However, the positive responses were not dose related (Hossack et al., (1978b). A micronucleus test (chromosomal damage) demonstrated comparable results between test rats and control rats when dosages of 2.8, 5.6 and 11.2 gm/kg of Cu-8 were administered by oral gavage (Hossack et al., (1978a). However, the NIOSH Directory of Suspected Carcinogens (1976) lists Cu-8 as a suspect carcinogen (Christensen et al., 1976). To date, the Agency has not validated the study(s) indicating the carcinogenic potential of Cu-8.

The above information indicates that Cu-8 has the potential for chronic adverse effects, specifically mutagenicity and oncogenicity. Further hazard and exposure evaluation is required prior to a final determination.

5. Copper Naphthenate

a. Acute Toxicology

When rats were dosed with 8.0% copper naphthenate, the acute oral LD_{50} was determined to be greater than 6.0 gm/kg (Rockhold, 1955). Rabbit eye irritation studies were negative for 8.0% copper naphthenate (Moldovan, 1969).

When Charles River rats inhaled 8.0% copper naphthenate for 1 hour, no deaths or overt pathological changes were observed after 14 days. The inhalation LC_{50} is greater than 105 mg/liter (Hathaway, 1971).

Similarily, an inhalation LC_{50} using 20% copper naphthenate could not be established for Sherman-Wistar rats. After 14 days, no lethal effects were observed at the highest dosage (19.1 mg/liter) after 1 hour of inhalation exposure (Levinson,1971).

Very little data are available with which to make a complete assessment of the acute effects of copper naphthenate. However, from the data that is available, inhalation exposure to 20.0% or less of copper naphthlenate does not appear to pose an unreasonable acute risk. Similarily, the acute oral LD_{50} is not considered to be excessive for 8.0% copper naphthenate.

b. Chronic Toxicology

Data are unavailable in the Agency's files to determine long-term effects of copper naphthenate.

6. Zinc Naphthenate

a. Acute Toxicology

When rats orally received a single dose of 8.0% zinc naphthenate, no deaths were reported at 6.0 gm/kg (Rockhold, 1955). Similarily an acute oral LD_{50} could not be established for Sherman-Wistar rats receiving a dose of 26.4% zinc naphthenate. The highest dose administrated was 5.0 gm/kg (Moldovan, 1971a).

Rabbits demonstrated no eye irritation after 3 days; and moderate erythema and moderate edema when 26.4% zinc naphthenate was applied to the eye (Moldovan, 1971c) and skin (Moldovan, 1971b) respectively.

As with copper naphthenate, the acute data base for zinc naphthenate is incomplete. From the data available it appears that formulations containing 26.4% or less zinc naphthenate may qualify for an unrestricted use classification. A final determination, however, cannot be made until all acute toxicology data requirements are fulfilled.

b. Chronic Toxicology

Data are unavailable in the Agency's files to determine long term effects of zinc naphthenate.

7. Trichlorophenol and Tetrachlorophenol

a. Introduction

This discussion will be limited to 2,4,5 and 2,4,6 trichlorophenol and to 2,3,4,6 tetrachlorophenol and their respective sodium salts. These isomers are the only chemicals in the tri and tetrachlorophenol group that are of commercial value as wood preservatives.

b. 2,4,5 Trichlorophenol (2,4,5 TCP)

On August 2, 1978 the Agency issued a Notice of Rebuttable Presumption Against Registration (RPAR) (43 FR August 2, 1978)) for 2,4,5 TCP and its salts. The notice and corresponding Position Document defines the risk criteria which have been exceeded by this pesticide. Specifically, the risks which have been deemed to be unreasonable are oncogenicity and fetotoxicity. Of the chlorophenols considered here, Firestone _et al_., (1972) identified 2,4,5 trichlorophenol (2,4,5 TCP), as containing 2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD). The Agency cannot determine if these effects are solely related to the TCDD impurity in 2,4,5 TCP, or if 2,4,5 TCP itself is inherently oncogenic and fetotoxic. Pure, uncontaminated 2,4,5 TCP is not available. There is evidence that TCDD has the potential to cause oncogenic and fetotoxic effects (43 FR August 2, 1978).

c. 2,4,6 Trichlorophenol (2,4,6 TCP)

The U.S. National Cancer Institute (1980) reported that 2,4,6 TCP was carcinogenic in a two year feeding study with F344 rats. Positive results, induction of lymphomas or leukemias, were only evident in male rats; 2,4,6 TCP did not cause cancer in the female test rats. However, in a corresponding 2 year feeding study using B6C3F1 mice, 2,4,6 TCP induced hepatocellular carcinomas or adenomas in both sexes.

d. 2,3,4,6 Tetrachlorophenol (2,3,4,6 Tetra)

The effect of both commercial and purified grades of 2,3,4,6 Tetra upon rat embryonal and fetal development was evaluated by Schwetz _et al_., 1974a). The authors concluded that the material at 30 mg/kg/day, is not teratogenic but was embryo and fetotoxic.

As mentioned earlier, Firestone _et al_., (1972) has identified the presence of hexachlorodibenzo-p-dioxin (HxCDD) impurities in 2,3,4,6 Tetra. Positive NCI studies have demonstrated the possible carcinogenicity of certain isomers of HxCDD. (see Sections II.D.4.c and II.D.5.b).

8. Summary

As discussed in the introduction, the data base utilized to define the toxicological characteristics of the alternatives to the RPAR chemicals is preliminary. It does not represent the entire data base available to the Agency nor do the studies meet all of the test methodology criteria considered appropriate.

The data base for the alternative wood preservatives is so deficient as to disallow a definitive assessment of the risks associated with use of the alternative wood preservatives. However, there is suggestive evidence to indicate that the acute toxicity of TBTO and Cu-8 may be unacceptable for unrestricted use. Similarily, the data for CZC, ACC, Cu-8, 2,4,5 TCP, 2,4,6 TCP and 2,3,4,6 Tetra indicate potential long term adverse effects. The toxicological potential of copper naphthenate and zinc naphthenate cannot be assessed on the basis of a few acute toxicology studies in which LD_{50} values could not be determined. In conclusion, from a safety point of view, the alternatives do not appear to be preferrable to the RPAR wood preservative.

III. BENEFIT ANALYSIS

A. Introduction

Part III contains the economic impact analysis of the wood preservatives creosote, inorganic arsenicals and penta by use category. This analysis is based, in large part, on material from the USDA-States-EPA Assessment Team (1980). This analysis evaluates the economic impact of the cancellation of one or more of the wood preservative agents in terms of the cost of substitution of the remaining registered wood preservative(s) or alternate materials (e.g., concrete). Based on data from 1977 to 1979, economic impacts are estimated for the wood preservative industry and projections are given for the resulting commodity impacts for users of the treated wood. Economic impacts are estimated on a national basis and, when possible, on a per unit of wood or per establishment basis. Local community economic impacts were not investigated due to the Agency's limited information in this area.

This part considers pressure and non-pressure uses of the wood preservative agents on a use-by-use basis. The first portion of Part III deals with the pressure uses of the wood preservative agents, namely: 1) railroad ties, 2) lumber, timber and plywood, 3) pilings, 4) posts, 5) crossarms and 6) poles. The remainding portion of Part III discusses the non-pressure uses of the wood preservatives: 1) poles-groundline, 2) home and farm, 3) sapstain control, 4) millwork and plywood and 5) particleboard.

B. Pressure Treatments

1. Profile of the Wood Treatment Industry

a. Introduction

The wood preservative treatment industry is comprised of establishments that treat wood with preservatives in retorts or open tanks [the 1972 Standard Industrial Classification (SIC 2491) manual (U.S. Dept. of Commerce, 1972)]. The 1977 Census of Manufactures (U.S. Dept. of Commerce, 1979), Dun and Bradstreet (1979), the American Wood Preservers Association (AWPA) survey and the USDA-States-EPA Assessment Report (1980) are major sources of data on the wood preservative industry. The pressure treatment use categories include: 1) railroad ties, 2) lumber, timber and plywood, 3) pilings, 4) posts, 5) crossarms and 6) poles. Although some plants only have the capability of treating wood in one or a limited number of these use categories, often plants have the capability to treat wood destined for the full range of uses presented above.

Many of these wood treatment plants are owned by small businesses which operate only one or two cylinders or treating tanks. However, in 1975 about half of the wood treating industry was controlled by ten companies (Fuller et al., 1977).

b. Usage of Wood Preservatives

The usage of creosote, inorganic arsenicals and penta for pressure wood treatments is summarized in Tables III-1 to III-5 by the volume of chemicals used as well as the volume of wood treated. Creosote is primarily used for railroad ties, penta for poles, and inorganic arsenicals for lumber and timbers.

In recent years, the wood treating industry has been substituting with either the fixed preservative treatments of chromated copper arsenate (CCA) or ammonical copper arsenate (ACA) for the non-fixed preservative treatment of fluor chrome arsenic phenol (FCAP). The volume of wood treated with FCAP has declined from 14.02 million cubic feet in 1967 to zero cubic feet in 1978. The usage of FCAP will likely disappear within a short period since FCAP is no longer manufactured in the United States, but is currently registered with EPA (USDA-States-EPA, 1980). Hence, the economic impacts of the cancellation of FCAP for the use categories lumber, timber and plywood, pilings, posts, crossarms and poles are considered to be small and was not subjected to further analysis.

TABLE III-1 Products Treated--All Preservatives[a], 1970-1974[b]

	1970	1971	1972	1973	1974
	- - - - - - - - - - - - -	1,000 cubic feet	- - - - - - - - - - - - -		
Crossties	79,384	87,029	85,880	67,603	75,870
Switchties	7,874	6,208	5,971	5,006	6,051
Lumber and timbers	52,105	56,303	59,700	64,762	73,692
Plywood[c]	(1,344)	(1,578)	(1,923)	(2,079)	(1,766)
Piling	15,128	13,699	14,324	12,978	13,315
Posts	15,106	16,669	18,175	15,168	17,304
Crossarms	3,454	3,075	2,487	2,592	2,416
Poles	76,760	74,374	74,537	75,379	73,112
Other	5,913	6,392	5,667	5,243	6,833
Total	255,724	263,749	266,741	248,731	269,043

a. Material treated with fire retardants not included. CZC and ACC included.

b. Source: USDA-States-EPA, 1980.

c. Plywood volume included in "other." Volumes shown include retardant treatments.

NOTE: Columns may not add to totals due to rounding.

TABLE III-1 Products Treated--All Preservatives[a], 1975-1978[b] (cont'd)

	1975	1976	1977	1978
	- - - - - - - - - 1,000 cubic feet - - - - - - - - - -			
Crossties	93,097	95,320	93,518	106,085
Switchties	7,959	5,728	6,708	
Lumber and timbers	58,135	63,626	60,396	107,579
Plywood[c]	(1,859)	(2,848)	(2,406)	(2,845)
Piling	9,403	8,478	11,346	12,114
Posts	15,311	13,769	10,735	20,105
Crossarms	1,424	4,628	1,347	1,692
Poles	49,144	53,143	52,531	64,179
Other	5,995	11,231	14,770	18,266
Total	240,468	255,923	251,351	330,020

a. Material treated with fire retardants not included. CZC and ACC included.

b. Source: USDA-States-EPA, 1980.

c. Plywood volume included in "other." Volumes shown include retardant treatments.

NOTE: Columns may not add to totals due to rounding.

TABLE III-2 Products Treated with Creosote Solutions[a], 1970-1974[b]

	1970	1971	1972	1973	1974
	------------- 1,000 cubic feet -------------				
Crossties	78,970	86,813	85,680	67,433	75,520
Switchties	7,812	6,144	5,917	4,999	6,453
Lumber and timbers	15,190	14,256	12,972	11,863	12,680
Piling	14,363	12,809	13,562	12,376	12,768
Posts	7,770	7,774	7,343	5,294	5,570
Crossarms	462	351	373	352	437
Poles	37,687	32,593	27,560	26,334	29,071
Other	2,612	2,417	2,144	1,940	2,445
Total	164,866	163,157	155,551	130,591	144,944

a. Creosote, creosote-coal tar, creosote-petroleum and creosote-penta.

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-2 Products Treated with Creosote Solutions,[a] 1975-1978[b] (cont'd)

	1975	1976	1977	1978
	1,000 cubic feet			
Crossties	92,658	95,165	91,281	103,138
Switchties	7,926	5,718	6,161	
Lumber and timbers	13,044	9,672	9,083	10,780
Piling	8,529	7,473	9,495	9,993
Posts	3,228	2,826	2,526	4,584
Crossarms	93	78	41	41
Poles	14,847	14,571	15,634	18,237
Other	3,078	3,501	7,782	7,815
Total	143,403	139,004	142,003	154,587

a. Creosote, creosote-coal tar, creosote-petroleum and creosote-penta.

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-3 Products Treated with Penta[a], 1970-1974[b]

	1970	1971	1972	1973	1974
	1,000 cubic feet				
Crossties	296	75	79	53	321
Switchties	51	52	50	7	---
Lumber and timbers	15,397	15,198	16,394	19,663	19,302
Piling	674	710	239	288	135
Posts	6,858	8,232	9,924	9,055	9,580
Crossarms	2,968	2,688	2,093	2,234	1,947
Poles	37,259	40,162	45,230	47,193	42,031
Other	2,183	2,380	1,786	1,528	2,450
Total	65,686	69,498	75,795	80,022	75,766

a. Petroleum-penta only, creosote-penta included in Table III-2.

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-3 Products Treated with Penta[a], 1975-1978[b] (cont'd)

	1975	1976	1977	1978
	- - - - - - - - -	1,000 cubic feet	- - - - - - - - - -	
Crossties	334	19	43	449
Switchties	24	---	376	
Lumber and timbers	15,837	13,837	9,931	21,209
Piling	384	368	1,042	1,154
Posts	9,953	9,096	6,791	10,983
Crossarms	1,301	4,541	1,299	1,615
Poles	32,155	36,525	33,193	41,905
Other	783	1,208	2,117	2,681
Total	60,771	65,630	54,789	79,996

a. Petroleum-penta only, creosote-penta included in Table III-2.

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-4 Products Treated with Inorganic Arsenicals[a], 1970-1974[b]

	1970	1971	1972	1973	1974
	1,000 cubic feet				
Crossties	116	141	121	116	29
Switchties	11	12	4	---	---
Lumber and timbers	19,635	24,161	27,503	30,146	38,704
Piling	90	179	522	314	412
Posts	479	660	904	786	2,120
Crossarms	24	36	21	6	29
Poles	1,813	1,619	1,747	1,854	1,833
Other	1,118	1,590	1,737	1,773	1,934
Total	23,286	28,398	32,559	34,995	45,061

a. CCA, ACA, FCAP

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-4 Products Treated with Inorganic Arsenicals,[a] 1975-1978[b]
(cont'd)

	1975	1976	1977	1978
	1,000 cubic feet			
Crossties	86	133	2,195	2,498
Switchties	9	---	171	
Lumber and timbers	27,331	37,354	39,108	73,317
Piling	484	564	785	943
Posts	2,023	1,837	1,341	4,461
Crossarms	30	8	---	29
Poles	1,277	1,423	3,704	4,038
Other	2,122	6,522	4,718	7,616
Total	33,362	47,841	52,022	92,903

a. CCA, ACA, FCAP.

b. Source: USDA-States-EPA, 1980.

NOTE: Columns may not add to totals due to rounding.

TABLE III-5 Products Treated and Preservatives Used 1970-1978[a, b]

Use Category	Year	Volume Treated	Preservative Used		
			Creosote Solutions	Penta	Inorganic Arsenicals
		1000 ft^3	- - - - - - - -	Percent	- - - - - - - -
1. Railroad ties crossties, switchties and scape ties)	1970	87,256	99.5	0.4	0.1
	1971	93,237	99.7	0.1	0.2
	1972	91,851	99.7	0.1	0.1
	1973	72,608	99.8	0.1	0.2
	1974	82,323	99.6	0.4	---
	1975	101,037	99.6	0.4	0.1
	1976	101,035	99.8	---	0.1
	1977	100,225	97.2	0.4	2.4
	1978	106,085	97.2	0.4	2.4
2. Lumber & timbers	1970	50,272	30.2	30.6	39.1
	1971	53,615	26.6	28.3	45.1
	1972	56,869	22.8	28.8	48.4
	1973	61,672	19.2	31.9	48.9
	1974	70,686	17.9	27.3	54.8
	1975	56,212	23.2	28.2	48.6
	1976	60,899	15.9	22.8	61.3
	1977	58,122	15.6	17.1	67.3
	1978	105,305	10.2	20.1	69.6
3. Piling	1970	15,127	94.9	4.5	0.6
	1971	13,698	93.5	5.2	1.3
	1972	14,323	94.7	1.7	3.6
	1973	12,978	95.4	2.2	2.4
	1974	13,315	95.9	1.0	3.1
	1975	9,397	90.8	4.1	5.2
	1976	8,405	88.9	4.4	6.7
	1977	11,322	83.9	9.2	6.9
	1978	12,090	82.7	9.5	7.8
4. Posts	1970	15,107	51.4	45.4	3.2
	1971	16,666	46.6	49.4	4.0
	1972	18,171	40.4	54.6	5.0
	1973	15,135	35.0	59.8	5.2
	1974	17,270	32.3	55.5	12.3
	1975	15,204	21.2	65.5	13.3
	1976	13,759	20.5	66.1	13.4
	1977	10,658	23.7	63.7	12.6
	1978	20,028	22.9	54.8	22.3

TABLE III-5 Products Treated and Preservatives Used 1970-1978 (cont'd)

Use Category	Year	Volume Treated	Preservative Used		
			Creosote Solutions	Penta	Inorganic Arsenicals
		1000 ft^3	Percent		
5. Crossarms	1970	3,454	13.4	85.9	0.7
	1971	3,075	11.4	87.4	1.2
	1972	2,487	15.0	84.2	0.8
	1973	2,592	13.6	86.2	0.2
	1974	2,413	18.1	80.7	1.2
	1975	1,424	6.5	91.7	2.1
	1976	4,627	1.7	98.1	0.2
	1977	1,340	3.1	96.9	---
	1978	1,685	2.4	95.8	1.7
6. Poles	1970	76,759	49.1	48.5	2.4
	1971	74,374	43.8	54.0	2.2
	1972	74,537	37.0	60.7	2.3
	1973	75,381	34.9	62.6	2.5
	1974	72,935	39.9	57.6	2.5
	1975	48,279	30.8	66.6	2.6
	1976	52,519	27.7	69.5	2.7
	1977	52,531	29.8	63.2	7.1
	1978	64,179	28.4	65.3	6.3
7. Other products	1970	5,913	44.2	36.9	18.9
	1971	6,387	37.8	37.3	24.9
	1972	5,667	37.8	31.5	30.7
	1973	5,241	37.0	29.2	33.8
	1974	6,829	35.8	35.9	28.3
	1975	5,983	51.4	13.1	35.5
	1976	11,231	31.2	10.8	58.1
	1977	14,617	53.2	14.5	32.3
	1978	18,113	43.1	14.8	42.1
8. All products	1970	253,838	64.9	25.9	9.2
	1971	261,053	62.5	26.6	10.9
	1972	263,905	58.9	28.7	12.3
	1974	245,608	53.2	32.6	14.2
	1974	265,771	54.5	38.5	17.0
	1975	237,536	60.4	25.6	14.0
	1976	252,475	55.1	26.0	18.9
	1977	248,814	57.1	22.0	20.9
	1978	327,485	47.2	24.4	28.4

a. Materials treated with creosote solutions, penta, and inorganic arsenicals only. ACC and CZC not included.

b. Source: USDA-States-EPA, 1980.

In 1977, 588 wood pressure treatment plants in the United States were listed with Dun and Bradstreet. The 1977 Census of Manufactures (U.S. Dept. of Commerce, 1979) and the 1977 AWPA survey (Maloney and Pagliai, 1978) identified 458 and 472 wood treating plants, respectively, in the United States. These sources may have missed many smaller plants, particularly those plants treating with inorganic arsenicals (Josephson, 1979)*.

Pressure treatment predominates in all regions of the country and accounts for 75% or more of treatment plants in each region, whereas non-pressure plants are most prevalant in the Rocky Mountains and Pacific regions and account for about 20% of all treatment plants in those regions. In 1976, for example, about 365 plants (88%) treated only with pressure, 30 plants (7%) used only non-pressure treatment, and the remaining 20 plants (5%) used both pressure and non-pressure treatment (Fuller _et_ _al_., 1977).

In 1977, of the total number of pressure treatment plants, about 177 used creosote, 194 used penta, and 181 treated with inorganic arsenicals; almost one half the wood preserving pressure treatment plants used more than one preservative compound (Josephson, 1979).

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* Discrepancy in these figures is due to the use of varying sources.

c. Employment and Revenue

In recent years, approximately 60% of the treatment plants employed fewer than 20 workers, whereas about 6% of the plants employed 100 or more workers (Dun & Bradstreet, 1979)*.

The total employment in the wood treatment industry in 1977 was 12,300 workers of whom 9,600 were employed as production workers and worked 18.7 million man hours (U.S. Dept. of Commerce, 1979). Production employment increased by 400 workers between 1972 and 1977, but total production man-hours actually decreased by 100,000 hours due to a reduction in the average annual hours worked per person. Although plants with 50 or more employees accounted for only 19% of the total workers, these plants produced 64% of the total value of treated wood for 1972.

The total value of treated wood shipments by treatment plants increased from $475.8 million in 1972 to $950.2 million in 1977 with the cost of materials purchased by the wood treatment industry increasing from $303.6 million in 1972 to $650.4 million in 1977. New capital expenditures in the wood treatment industry increased from $14.8 million in 1972 to $30.3 million in 1977

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* Similarly, in 1972 plants with 100 or more workers employed over 5% of the total workers compared with plants with less than 20 workers which employed 58% of the total workers (U.S. Dept. of Commerce, 1975).

(U.S. Dept. of Commerce, 1975, 1979). Expenditures for capital investment and non-labor inputs are expanding more rapidly than the expenditures for labor inputs.

2. Comparative Costs of Wood Preservative Compounds, Their Future Availability and Price, and the Projected Service Life of Treated Wood

This section provides a brief survey of the availability of the three major wood preservatives and expected price trends. The availability of raw materials, trends in raw material prices, and manufacturing capacity are important variables influencing the future availability and price of the wood treatment chemicals.

a. Introduction

All untreated wood products, regardless of their original strength, durability or natural resistance, are subject to degradation when placed in end-use situations which are conducive to attack by fungi, insects, bacteria or marine borers. The application of selected chemicals as wood preservatives protects wood from deterioration and frequently yields a product with significant advantages in terms of cost and performance (e.g., more versatility with wood than non-wood products) over non-wood alternatives that might be available.

The actual service life of treated wood products depends on the treated wood's inherent resistance to decay as well as on the environmental conditions of end-use such as marine immersion or ground contact (USDA-States-EPA, 1980). An increase in life expectancy of five or more times that of untreated wood is achieved for most treated wood products.

b. Comparative Costs of Wood Preservatives and Service Life of Treated Wood

Table III-6 presents the cost of several different preservative formulations used for pressure treatments per cubic foot of wood [derived from the price per pound of the preservative times the retention rate (pounds cubic foot)]. Table III-7 presents the chemical retention rates for various wood products and the projected service lives of these products. This information is used to derive the comparative costs of the preservative treatment for the several preservative agents on a use-by-use basis.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979

Product	Creosote			Coal Tar
Retention (pounds per cubic foot)	8	9	12	---
Unit	- - - - - gallon - - - - -			gallon
Weight per unit	- - - - 9 pounds - - - -			10 pounds
Price per unit	- - - - $ 0.83 - - - - -			$ 0.80
Price per pound of preservative	- - - - $ 0.092 - - - -			$ 0.080
Cost of preservative per cubic foot	$ 0.738	$ 0.830	$ 1.106	---

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a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Creosote-Coal Tar[b]			Petroleum	
				P9, Type A	P9, Type B
Retention (pounds per cubic foot)	8	9	12	—	—
Unit	- - - - - gallon - - - -			gallon	gallon
Weight per unit	- - - - 9.5 pounds - - -			7.5 pounds	7.1 pounds
Price per unit	- - - - $ 0.815 - - - -			$ 0.70	$ 0.82
Price per pound of preservative	- - - - $ 0.086 - - - -			—	—
Cost of preservative per cubic foot	$ 0.687	$ 0.772	$ 1.029	—	—

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a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

b. Creosote-Coal Tar is a 50% solution.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Penta	Penta and P9, Type A[c]			
Retention (pounds per cubic foot)	---	0.3[d]	0.4[d]	0.5[d]	0.6[d]
Unit	pound	gallon			
Weight per unit	1 pound	7.9 pounds			
Price per unit	$ 0.53	$ 0.99			
Price per Pound of Preservative	---	$ 1.77[d]			
Cost of Preservative per cubic foot	---	$0.530	0.707	0.884	1.061

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a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

c. Penta, Type A is a 7% penta solution.

d. Price is based on pounds of penta in formulation.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Penta and Co solvent[e]	Penta and P9, Type C[f]		
Retention (pounds per cubic foot)	---	0.3[d]	0.4[d]	0.5[d]
Unit	gallon	gallon		
Weight per unit	8.0 pounds	7.3 pounds		
Price per unit	$3.30	$1.33		
Price per pound of preservative	---	$3.33[d]		
Cost of preservative per cubic foot	---	$1.00	$1.33	$1.66

a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

d. Price is base on pounds of penta in formulation.

e. Penta and Co solvent is a 22% penta solution.

f. Penta and P9, Type C is a 5 % penta solution.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	CCA/ACA					
Retention (pounds per cubic foot)	0.25	0.32	0.40	0.60	0.80	2.50
Unit	pound					
Weight per unit	1 pound					
Price per unit	$1.00					
Price per pound of preservative	$1.00					
Cost of preservative per cubic foot	$0.25	$0.32	$0.40	$0.60	$0.80	$2.50

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a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Copper Naphthenate[g]	Cu Naph and P9, Type A[h]					
Retention (pounds per cubic foot)	---	0.45[i]	0.60[i]	0.68[i]	0.75[i]	0.90[i]	1.20[i]
Unit	pound	gallon					
Weight per unit	1 pound	8.6 pounds					
Price per unit	$ 0.90	$ 4.27					
Price per pound of preservative	---	$12.41[i]					
Cost of preservative per cubic foot	---	$5.58	$7.45	$8.44	$9.31	$11.17	$14.89

a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

g. Copper naphthenate is a 8% copper formulation.

h. Cu naph and P9, Type A is a 4% copper formulation.

i. Price is based on pounds of copper in formulations.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Cu Naph and P9, Type C[h]			
Retention (pounds per cubic foot)	0.45[i]	0.60[i]	0.68[i]	0.75[i]
Unit	gallon			
Weight per unit	8.2 pounds			
Price per unit	$ 4.19			
Price per pound of preservative	$12.77[i]			
Cost of preservative per cubic foot	$5.75	$7.66	$8.69	$9.58

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a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

i. Price is based on pounds of copper in formulation.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	Cu-8[j]	Cu-8 and P9, Type C[k]	
Retention (pounds per cubic foot)	---	0.12[l]	0.16[l]
Unit	pound	- - - gallon - - - -	
Weight per unit	1 pound	- - 7.25 pounds - -	
Price per unit	$18.00	- - - - $3.32 - - - -	
Price per pound of preservative	---	- - - $23.75[l] - - - -	
Cost of preservative per cubic foot	---	$2.85	$3.79

a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

j. Price is based on a solubilized Cu-8 formulation.

k. Cu-8 and P9, Type C is a 2% Cu-8 formulation.

l. Price is based on pounds of Cu-8 in formulation.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	TBTO	TBTO and P9, Type C[m]	
Retention (pounds per cubic foot)	---	0.12[n]	0.16[n]
Unit	pound	- - - gallon - - -	
Weight per unit	1 pound	- - 7.25 pounds - -	
Price per unit	$6.65	- - - $1.73 - - - -	
Price per pound of preservative	---	- - - $12.33[n] - - -	
Cost of preservative per cubic foot	---	$1.48	$1.98

a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

m. TBTO and P9, Type C is a 2% TBTO solution.

n. Price is based on pounds of TBTO in formulation.

TABLE III-6 Price of Preservative Chemicals[a] and Solvents, and Cost of Formulations per Cubic Foot of Wood Treated, 1979 (continued)

Product	CZC	ACC		
Retention (pounds per cubic foot)	0.45	0.25	0.50	0.62
Unit	pound	-----	pound	-----
Weight per unit	1 pound	----	1 pound	-----
Price per unit	$0.50	-----	$1.25	-----
Price per pound of preservative	---		---	
Cost of preservative per cubic foot	$0.225	$0.313	$0.625	$0.775

a. Prices of chemical developed by USDA-States-EPA Assessment Team in consultation with industry representatives, October, 1979.

TABLE III-7[a] Use Category, Recommended Preservative, Retentions, and Service Life

Use Category	Preservative	Retention (pcf)	Service Life (years)
1. Railroad ties			
Crossties and switchties	Creosote	8.00	35
	Creosote/Coal-Tar	8.00	35
	Penta	0.40[b]	25
	Cu Naph	0.60[b]	25
2. Lumber, timber and plywood			
a. Industrial block flooring	Creosote	8.00	50+
	Creosote/Coal-Tar	8.00	50+
b. Cooling tower slats	ACC[c]	0.50	20
	CCA/ACA	0.40	20
c. Agricultural uses and nurseries	ACC[c]	0.62	30
	Cu Naph	0.75[b]	30
	CCA/ACA	0.50	30
d. Landscape timbers and decking	ACC[c]	0.50	30
	CCA/ACA	0.40	30
	Penta	0.50	30
e. Containers (boxes, crates, etc.)	CZC[c]	0.45	—
	ACC[c]	0.25	—
	Cu-8	0.12	—
	TBTO	0.12	—
	Cu Naph	0.45[b]	—
	CCA/ACA	0.25	—
	Penta	0.30	—
f. Boat hulls and decks	CCA/ACA	0.60	—
g. Sea walls, wharves, piers-salt water	Creosote	25.00	20
	Creosote/Coal-Tar	25.00	20
	CCA/ACA	2.50	30
h. Bridges, crossing planks	Creosote	12.00	35
	Creosote/Coal-Tar	12.00	35
	Penta	0.60	35
	CCA/ACA	0.60	35

TABLE-7[a] Use Category, Recommended Preservatives, Retentions and Service Life (cont'd)

Use Category	Preservative	Retention (pcf)	Service Life (years)
i. Mines ties and timbers	ACC[c]	0.50	30
	Creosote	10.00	30
	Creosote/Coal-Tar	10.00	30
	Penta	0.50	30
	CCA/ACA	0.40	30
	Cu Naph	0.75[b]	30
j. House foundations, swimming pools	CCA/ACA	0.60	50+
k. Playground equipment	ACC[c]	0.50	30
	CCA/ACA	0.40	30
l. Highway sound barriers	Penta	0.60	35
	CCA/ACA	0.60	35
m. Residential, commercial-misc., construction, lumber and plywood, nonstructural (above ground only)	ACA[c]	0.25	50+
	CZC[c]	0.45	50+
	Cu-8	0.12	50+
	TBTO	0.12	30
	Penta	0.30	50+
	CCA/ACA	0.25	50+
n. Farm, industrial misc., construction lumber and plywood, nonstrutural (above ground only)	ACC[c]	0.25	35
	CZC[c]	0.45	35
	CCA/ACA	0.25	50
	Cu-8	0.16	35
	TBTO	0.16	25
	Cu Naph	0.60[b]	50
	Creosote	8.00	50
	Creosote/Coal Tar	8.00	50
	Penta	0.40	50
3. Piling			
a. Marine	Creosote	20.00	20
	Creosote/Coal-Tar	20.00	20
	CCA/ACA	2.50	30

TABLE III-7[a] Use Category, Recommended Preservatives, Retentions and Service Life (cont'd)

Use Category	Preservative	Retention (pcf)	Service Life (years)
b. Foundation, fresh water, land	Creosote	12.00	50+
	Creosote/Coal-Tar	12.00	50+
	Penta	0.60	50+
	CCA/ACA	0.80	50+
	Cu Naph	1.20	50+
4. Posts			
a. Fence-farm and highway	ACC[c]	0.50	35
	Creosote/Coal-Tar	6.00	25
	Creosote	6.00	25
	CCA/ACA	0.40	35
	Cu Naph	0.45[b]	35
	Penta	0.30	25
b. Fence-residential and commercial	ACC[c]	0.50	35
	CCA/ACA	0.40	35
	Penta	0.30	25
c. Highway-guard rail and sign	Creosote	12.00	30
	Creosote/Coal-Tar	12.00	30
	Penta	0.60	30
	CCA/ACA	0.60	30
	Cu Naph	0.90[b]	30
5. Crossarms	ACC[c]	0.50	40
	Penta	0.40	40
	CCA/ACA	0.40	40
	Cu Naph	0.60	40
	Creosote	8.00	40
6. Poles			
a. Utility	Creosote	9.00	35
	Penta	0.45	35
	CCA/ACA	0.60	50
	Cu Naph	0.60[b]	35
b. Residential	Penta[d]	0.80	50+
	CCA/ACA	0.80	50+

TABLE III-7[a] Use Category, Recommended Preservatives, Retentions and Service Life (cont'd)

Use Category	Preservative	Retention (pcf)	Service Life (years)
c. Farm and industrial	Creosote	9.00	35
	Creosote/Coal-Tar	9.00	35
	Penta	0.45	35
	CCA/ACA	0.60	50
	Cu Naph	0.68[b]	35
d. Recreational and commercial	Penta	0.60	35
	CCA/ACA	0.60	50

a. Source: USDA-States-EPA, 1980.

b. Based on copper metal.

c. Due to limited uses of ACC and CZC; they are not being considered as the most likely substitutes for cancellation. The service life of FCAP-treated wood is about 5 to 10 years compared to about 30 to 50 years for ACA- and CCA-treated wood depending on exposure to natural elements.

d. Exterior use only.

c. Future Availability and Price of Creosote

In 1978, about 99% of the 124 million gallons of creosote, coal tar and coal tar neutral oils were used for wood preservation in the United States (USDA-States-EPA, 1980). An estimated 357.6 million gallons of coal tar were required to produce the creosote used by the wood preservative industry in 1976 (Fuller et al., 1977). In 1978, about 71 million tons of coal were carbonized by coke producers and yielded an estimated 540.6 million gallons of coal tar. About 9.9 million gallons of the estimated 540.6 million gallons of coal tar were burned as fuel (Energy Information Administration, 1979). In addition, creosote is produced as a by-product of the process for making pitch. In 1976, 23.9 million gallons of creosote produced from pitch were burned as fuel.

Consequently, creosote availability for wood treatment could be increased by diverting the creosote currently burned as fuel. Current coal tar or creosote supplies appear adequate to permit creosote consumption to increase 20% to 30%, but the price of creosote (approximately $0.80 to $0.88 per gallon) will be directly related to the pricing of #6 fuel oil which has an equivalent BTU value.

d. Future Availability and Price of Inorganic Arsenicals

i. The Supply and Price of CCA and ACA Components

The raw ingredients required for the production of CCA or ACA include arsenic acid, chromic acid and copper. The wood treatment industry uses about 60% of all arsenic acid produced in the United States for the production of CCA or ACA (Toth, 1979). The Pennwalt Corporation, which produces a large proportion of the arsenic acid, has currently enlarged its production facilities and could double or triple the present capacity by installing additional reaction vessels. Thus, there should be sufficient arsenic acid to meet the future needs of the wood treatment industry (Toth, 1979).

The December, 1979 price of arsenic acid sold in truckload lots (Freight on Board price) was $4.95 per gallon (15.7 pounds), or about twice the 1976 price. The increase in price of arsenic acid during this period was due, in part, to the increased demand for inorganic arsenical wood preservatives, which have become more competitive with creosote and penta wood preservatives.

About 20% of the estimated 50,000 tons of chromic acid produced in the United States is used by the wood treatment industry and the remaining 80% by the metal plating industry, the largest single user of chromic acid. The market for chromic acid is shifting to the wood treatment industry due to the recently increasing demand for the inorganic arsenical wood preservatives, the decline in demand for chromium for use in automobiles, and the recycling of chromium associated with pollution cleanup efforts by the metal plating industry (Gilbert, 1979; O'Brien, 1979). The Diamond Shamrock Corporation can increase its chromic acid production capacity by 25% to 30% which will increase the national production of chromic acid by 10% to 12%.

There appears to be no problem with the future availability of copper, the third component of CCA and ACA formulations. However, changes in copper prices would have the largest impact on the price of ACA. For example, the price of ACA would increase about $0.12 per pound if the price of copper increased 30%.

ii. The Supply and Price of CCA and ACA

The wood treatment industry has been expanding its production capacity for CCA and ACA in response to the increased use of inorganic arsenicals for wood treatment. Osmose Wood Preserving Company of America, Inc., a major producer of CCA, could expand its production capacity by 20% with a lag time of about six or seven months (O'Brien, 1979).

The December, 1979 selling price of CCA and ACA treatment solutions, as well as FCAP solutions, was about $1.00 per pound. Of this figure, about $0.78 represents the cost of raw materials and the other $0.22 reflects the cost of mixing, transportation, administration and other business costs. However, increases in preservative prices for ACA and CCA may not result in large increases in the cost of installed treated wood since preservative costs represent only a small fraction of the total installation cost (EPA, 1980).

e. Future Availability and Price of Penta

The penta industry in the United States has a capacity of about 80 million pounds per year with current annual penta production in the range of 40 and 50 million pounds (Johnson, 1979). There are no supply problems expected with the basic raw materials used in the production of penta or of penta's salt formulations.

Increased fuel oil prices are especially critical for the penta wood treatment industry because large amounts of petroleum are used as a wood treatment solvent. As an indication of current trends, the price of penta increased about 13%, from $0.46 to $0.52 per pound, as a result of fuel price changes between August 1979 and January 1980.

3. Capital Requirements for Plant Conversion to Alternative Treatments

When converting from creosote or penta to inorganic arsenicals, additional capital investment for equipment changes is needed because of differences in mixing and storage facilities. The necessary equipment changes can be made by (1) either retrofitting existing treatment cylinders or by constructing new cylinders and by (2) constructing the wood drying kilns which are necessary for treatment with the inorganic arsenicals. A kiln is necessary for inorganic arsenical treatments because the wood must be dry before treatment can be carried out. If new cylinders were constructed, the estimated minimum investment (assuming that the required handling equipment for the treated wood already exists at the treatment plant) would range between $275,000 and $325,000 per cylinder (McGill, 1979).

The conversion of existing cylinders for use with other wood preservatives would be less expensive, require less time, and cause less employment and community disruption than the construction of new treatment cylinders (McGill, 1979). The wood treatment industry would most likely convert existing cylinders rather than install new treatment cylinders. Conversion of a creosote or a penta cylinder for use with inorganic arsenicals would involve cleaning the cylinder, installing some piping and constructing mixing and storage facilities for the inorganic arsenical salts. A converted cylinder would cost between $20,000 and $30,000 per cylinder and have an annual capacity of treating about 600,000 cubic feet of wood, assuming two charges per day (McGill, 1979).

The additional capital investment for kilns when converting from creosote and/or penta to inorganic arsenical treatment ranges between $100,000 and $200,000. The two major types of wood

kilns used in the United States are conventional temperature (71 to 82°C) and high temperature (110°C plus) kilns.
The capacity of these kilns is determined by the time required for drying, which is dependent upon kiln size, drying temperature, and the type and volume of wood species being dried. For example, southern pine lumber can be dried in a high temperature kiln within 24 hours, whereas a hardwood species, such as oak, must be dried at conventional temperatures and requires 25 to 30 days. Depending on type and size, each kiln would have an annual capacity ranging from 204,400 cubic feet of wood (about 10,000 poles) to 1.4 million cubic feet of lumber, as shown in Table III-8.

TABLE III-8 Capital Requirements for Wood Drying Kilns[a]

Item		Cost
Kiln A - 26' x 52' Conventional Temperature Kiln		
1.	Equipment, building and control room (equipment alone = $35,000)	$ 80,500
2.	100 horsepower boiler	16,000
3.	Erection of building and equipment installation	19,000
4.	Site preparation and building slab	9,000
	Total	$124,500
Kiln B - 28' x 30' Conventional Temperature Kiln		
1.	Equipment, building and control room	$ 70,000
2.	60 horsepower boiler	14,000
3.	Erection of building and equipment installation	15,000
4.	Site preparation and building slab	9,000
	Total	$108,000
Kiln C - 32' x 54' High Temperature Kiln		
1.	Equipment, building and control room	$108,000
2.	500 horsepower boiler	50,000
3.	Erection of buildings and equipment installation	31,000
4.	Site preparation and building slab	12,000
	Total	$200,000

a. Source: James Palmer, Irvington Moore Dry Kiln Co., Jacksonville, Florida (site preparation and building slab cost estimated by EPA).

4. Methods and Assumptions

Scenarios are used throughout Part III to project the economic impacts of cancelling one, two or all of the three major wood preservatives. Since the three wood preservatives are, in most cases, alternatives for each other, the cancellation of one or two of the wood preservative agents is analyzed in terms of the increased use of the available alternatives, wherever appropriate. If all three major wood preservatives were cancelled, economic impacts are analyzed for the most likely alternative (e.g., concrete, steel, etc.) for that use. In the presentation of the economic impacts attributable to the various cancellation scenarios, the range of the cost impacts are presented in the text and the impacts for each individual scenario are fully detailed in the accompanying tables. The scenario numbers for each use pattern are presented in the first reference table for that use.

There are several factors used throughout Part III as a basis for the derivation of the projected economic impact resulting from the cancellation of one, two or all of the three major wood perservatives. These factors, namely the future availability of the wood preservative agents, preservative costs, service life of the treated wood, capital investment for equipment changes and installation costs, are used to obtain an adjusted cost of treated wood compared to the 1978 actual cost of treated wood. Various assumptions have been made in estimating the cost of these factors, including the assumption of a 50% increase in preservative cost resulting from increased demand for the remaining registered pesticide under certain cancellation scenarios, the availability of the alternative wood preservative agents, the growth in the use patterns and the absence of technological innovations. The assumptions made in the analyses regarding the impact of possible cancellation actions are stated in detail in the Preliminary Benefit Analysis (EPA, 1980); any specific assumptions made for a particular use category are noted, as appropriate.

The economic impact of cancellation for one or more of the three wood preservatives would result in changes in the cost of treated wood or the cost of maintenance of the treated wood system. These costs are determined for each possible cancellation scenario and compared to the 1978 cost. The difference between the adjusted cost of treated wood and the 1978 cost of treated wood is the economic impact on the price of the treated wood product. The derivation of the adjusted cost of the treated wood for each scenario requires several steps. The first step involves determining any differences in current preservative costs for the alternative preservative agents. The next step in adjusting the determination is factoring in the additional capital investment for equipment changes required to convert the plants to the use of alternative preservatives. In order to determine the annual cost attributed to this capital investment, the total capital cost (including 12% interest costs to borrow the funds) is amortized over a period of ten years. The final step is to incorporate a factor into the adjusted cost determination a term which reflects the increased demand for preservatives (when there is increased demand for a product with a fixed supply, the product price generally increases). The Agency believes that an increase in preservative prices is likely to occur if one or more of the wood perservative agents were cancelled and has selected a 50% increase in preservative prices as an estimate of the maximum plausible increase for this effect. To summarize, the adjusted cost of treated wood on a use-by-use basis for each cancellation scenario results from a consideration of the change in preservative cost (based on current prices) as modified by an estimated 50% price increase, where appropriate, and the annual costs attributable to the capital investment required to convert the plants to the alternative wood preservative treatment process.

For the end-use patterns of treated wood systems with extended service lives (e.g., railroad ties and utility poles), cost impacts were estimated in terms of the average annual cost for maintaining the system, or "annualized cost." The concept of "annualized cost" has particular relevance for achieving a comparison of alternatives which impart differing service lives to the treated wood products. The annualized cost represents the average amount of money which must be invested each year to maintain a system over a finite time period. To calculate the annualized cost for a given scenario, the annual replacement and maintenance costs are first estimated for each year for each alternative scenario, assuming that the current system size remains constant. In order to determine the amount which theoretically would have to be invested in the first year to allow the proceeds (principal and interest) to equal the total cost, the total replacement and maintenance costs are then reduced to a figure which represents the present value of these future costs. The formula for determining "present value" is as follows:

$$\text{Present value} = \sum_{n=1}^{100} \frac{C_n \times 1}{(1 + r)^n}$$

where C_n equals cost in year n

and r equals interest rate at 10%

The present value is then amortized over the finite time period under consideration to determine the "annualized" cost for each alternative scenario, using the following formula:

$$\text{Annualized cost} = \frac{\text{Present value} \times r(1 + r)^n}{(1 + r)^n - 1}$$

It should be noted that the annualized cost is not equal to any actual individual actual cost, but merely represents the theoretical cost attributable to each year.

5. Benefit Analysis by Use Category for Pressure Treatments

a. Railroad Ties

i. Usage and Identification of Use Category

In 1978, 106 million cubic feet of railroad crossties and switchties were treated with wood preservatives. About 2.5 million cubic feet of these ties were treated with inorganic arsenicals and were used primarily for landscaping purposes. The treated ties used as landscape or garden timbers are considered under the use category of lumber, timber and plywood. Of the remaining 103.5 million cubic feet of treated ties (about 31 million ties), approximately 99.6% were treated with creosote (about 103.1 million cubic feet) and 0.4% with penta (about 0.5 million cubic feet). The high usage of creosote-treated ties reflects the higher strength and lower cost of the creosote-treated ties compared with other preservative-treated wood ties. These creosote- and penta-treated ties are annually used by the United States railroads for new construction (5%) and maintenance of existing systems (95%). The Association of American Railroads expects annual tie replacement to remain at current levels (Josephson, 1979).

ii. Assumptions

The estimated average service life for both creosote-treated ties and concrete ties, and for both penta-treated and copper naphthenate-treated ties is considered to be 35 years and 25 years, respectively (USDA-States-EPA, 1980). The economic impacts projected in this section are based on the assumption that there will be adequate production capacity to produce the concrete or penta-treated tie replacement systems and that these alternative materials would be available at current prices. Inorganic arsenical treatment is considered to be unacceptable for railroad tie use because inorganic arsenical-treated ties are brittle and do not hold fasteners well (USDA-States-EPA, 1980).

iii. Impacts of Cancellation

Since inorganic arsenical-treated ties are not currently used in the construction of railroad tracks, the impact of cancellation of inorganic arsenicals for this use category is not considered.

Since a small percentage of railroad ties is treated with penta (<0.4%), the use of creosote or some other alternative (e.g., copper naphthenate, concrete) could easily replace the use of penta for railroad ties. Hence, the economic impact of the cancellation of penta for this use is also considered to be very small and was not subjected to further analysis.

The cancellation of creosote would result in converting the entire railroad tie system to another type of tie system since 99% of railroad ties are treated with creosote. The cost impact of cancelling creosote and converting the railroad tie system to either penta, concrete or copper naphthenate was analyzed in terms of the "annualized" or average annual cost; the definition of this concept and the methodology used for the determination is discussed in Section III.B.4, Methods and Assumptions. The estimated annualized costs of creosote-treated, penta-treated, copper naphthenate-treated and concrete tie systems for the 300,000 miles of United States railroads are shown in Table III-9.

The initial, per mile, installed cost of penta-treated ties is slightly lower than those treated with creosote and the first year impact would consist of a lower cost for replacement ties. The annualized cost of converting from a creosote-treated tie system to a penta-treated tie system would be $1.027 billion (Table III-9), an increase of $40.5 million annually over the annualized cost of the current primarily creosote-treated tie system. The difference between the annualized cost of the creosote- and penta-treated tie systems is due primarily to the reduced service life of penta-treated ties. This scenario would require an additional 34.6 million pounds of penta and 61 million gallons of oil, thereby doubling the current consumption of penta. It has been estimated that a lead time of 3 years and an investment of $14 million would be required to sufficiently expand penta production to satisfy the demand for treatment of ties if creosote were cancelled (Fuller _et_ _al_., 1977).

TABLE III-9 Estimated Costs of Using Treated Wood Ties and Concrete Ties on United States Railroads

Item	Creosote-Treated Wood Ties	Penta-Treated Wood Ties
Ties--each	$14.50[a]	$13.80[b]
Hardware--per tie[a]	8.50	8.50
Freight--per tie[a]	1.50	1.50
Installation--per tie[a]	10.00	10.00
Total installed cost	$34.50	$33.80
Number per mile[a]	3,033	3,033
Service life[c]	35 years	25 years
	-------- Million Dollars -------	
Present value of future costs[d]	$9,865[e]	$10,270[f]
Average annual cost[h]	986.5	1,027.0

a. From Josephson, 1979.

b. Based on current preservative prices and recommended retention (Table III-6).

c. From Table III-7.

d. Of maintaining system with creosote or converting to penta, cu naph, or concrete; over 100 years at 10%.

e. Based on 26 million ties per year for 100 years.

f. Based on 26 million ties per year for 25 years, 52 million ties per year for 10 years, 26 million ties per year for 15 years, 52 million for 10 years, 26 million ties per year for 15 years, etc.

g. Based on 75.24 million ties per year for 10 years, 39.6 million per year for 1 year, 0 ties for 24 years, 75.24 million per year for 10 years, etc.

h. Average annual cost $= \dfrac{\text{Present value } \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

TABLE III-9 Estimated Costs of Using Treated Wood Ties and Concrete Ties on United States Railroads (continued)

Item	Copper Naphthenate-Treated Wood Ties	Concrete Ties
Ties--each	$36.85[b]	$32.00[a]
Hardware--per tie[a]	8.50	8.50
Freight--per tie[a]	1.50	4.00
Installation--per tie[a]	10.00	16.00
Total installed cost	$56.85	$60.50
Number per mile[a]	3,033	2,640
Service life[c]	25 years	35 years
	- - - - - - - - Million	Dollars - - - - - - -
Present value of future costs[d]	$17,258[f]	$32,859[g]
Average annual cost[h]	1,725.8	3,285.9

a. From Josephson, 1979.

b. Based on current preservative prices and recommended retention (Table III-6).

c. From Table III-7.

d. Of maintaining system with creosote or converting to penta, cu naph, or concrete; over 100 years at 10%.

e. Based on 26 million ties per year for 100 years.

f. Based on 26 million ties per year for 25 years, 52 million ties per year for 10 years, 26 million ties per year for 15 years, 52 million for 10 years, 26 million ties per year for 15 years, etc.

g. Based on 75.24 million ties per year for 10 years, 39.6 million per year for 1 year, 0 ties for 24 years, 75.24 million per year for 10 years, etc.

h. Average annual cost $= \dfrac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

The use of copper naphthenate as a replacement for creosote would result in a substantially higher per mile initial installed cost. The first year impact would consist of a higher cost for replacement ties or an impact of a $605.7 million. The annualized cost of converting from creosote-treated tie system and maintaining a copper naphthenate-treated tie system would be $1.725 billion (Table III-9), or an average annual cost increase of $739.3 million over the annualized cost of the current creosote-treated tie system.

Concrete ties are considered technically feasible substitutes for treated wood ties on United States railroads, but their service life has yet to be determined (USDA-States-EPA, 1980). However, treated wood ties and concrete ties cannot be intermixed in a given system* and the replacement of creosote-treated ties with concrete ties would necessitate the replacement of all the ties in a given section of the railroad tie system. The replacement of the current 28,500 miles of track maintained annually with concrete ties would require 2,640 ties per mile or 75,240,000 concrete ties annually. Assuming that this number of concrete ties could be produced and installed annually, the first year cost for this conversion would be $4.552 billion. This annual cost would continue for 10.5 years until the entire United States railroad system was converted to concrete ties. The annualized cost of converting and maintaining the railroad system with concrete ties would be $3.3 billion, an average annual cost increase of $2.3 billion over the annualized cost of the current primarily creosote tie system.

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* Experience has shown that concrete ties do not preform satisfactorily when randomly interspersed with treated wood tie track. Concrete ties settle more slowly, resulting in an unstable track structure. The greater weight of concrete ties is also an impediment to their installation by conventional maintenance methods and equipment. Most equipment would have to be modified to handle heavier concrete ties (USDA-States-EPA, 1980).

iv. Limitations of the Analysis

The above projected enconomic impacts are based on the assumptions that the supply of alternative materials is adequate for substitution at current prices. The adverse economic impacts of cancelling creosote and/or penta on the wood producing and wood treating industries have not been quantitatively assessed, but is projected to be substantial if these preservatives were cancelled for use on railroad ties.

b. Lumber, Timber and Plywood

i. Usage and Identification of Use Category

Treated lumber is now used in many places formerly served almost exclusively by cedar and redwood. Shorter supplies and higher prices of these wood species have resulted in greater demand for treated wood in a variety of end-uses. Inorganic arsenical-treated wood, which is suitable for almost all end-uses of lumber, timber and plywood, has been the primary replacement material for cedar and redwood.

Accurate data on the volumes of treated lumber, timber and plywood used for a specific end-use are lacking and are difficult to obtain due to the large number of end-uses and users involved. The USDA-States-EPA Assessment Team (1980) divided the end-uses of treated lumber, timber and plywood into five general end-use categories as shown in Table III-10. The estimated volumes of treated lumber and timber produced in 1978 for each end-use category are shown in Table III-11 (plywood volumes are not included in this table). Approximately 80% of the plywood is treated with inorganic arsenicals (excluding fire retardant treatment). Treated plywood is used with treated lumber and its use patterns are assumed to be similar to those for treated lumber.

An estimated 105.3 million cubic feet of lumber and timber were treated with the three wood preservatives with an estimated preservative cost of $66.2 million in 1978. In addition, more than 2 million cubic feet of plywood and a substantial amount of sawn material (e.g., crossing planks, mine timbers, highway posts and agricultural wood products) were treated and fall into this use category.

TABLE III-10 Use of Treated Lumber, Timbers and Plywood[a]

End-use Area	Lumber, Timber and Plywood Treated with			
	Creosote	Penta	CCA	ACA
	---------- Percent ------			
Residential and commercial construction	3	2	65	75
Farm and industrial construction	12	40	5	10
Recreation	1	15	15	5
Marine	45	3	10	5
Transportation	40	40	5	5

a. Estimates developed by the USDA-States-EPA Assessment Team in consultation with industry representatives, Boston, MA, August 17, 1979.

NOTE: Columns may not add to 100 due to rounding.

TABLE III-11 Volume of Treated Lumber and Timbers, by End-use, 1978[a]

End-use Area	Lumber and Timbers Treated with				
	All Preservatives	Creosote	Penta	CCA	ACA
	----------- 1,000 cubic feet ------				
All uses	105,305	10,780	21,209	63,317	10,000
Residential and commercial construction	49,403	323	424	41,156	7,500
Farm and industrial construction	13,994	1,294	8,484	3,166	1,000
Recreation	13,287	108	3,181	9,498	500
Marine	12,265	4,797	636	6,332	500
Transportation	16,408	4,258	8,484	3,166	500

a. Based on Tables III-5 and III-10.

In 1978, creosote was used for treating about 10.78 million cubic feet of lumber and timber, or about 10% of the treated lumber and timber. Industrial block flooring accounts for about 700 thousand cubic feet of creosote-treated lumber; the other 10.08 million cubic feet of creosote-treated wood in this use category are used primarily as timbers for landscape, farm, mine and marine construction purposes.

More than 70% of the total treated lumber and timber, about 73.32 million cubic feet, was treated with inorganic arsenicals and about 20%, or about 21.21 million cubic feet of lumber and timber, was treated with penta in 1978 (USDA-States-EPA, 1980). Table III-11 gives the volumes of treated lumber and timber, by end-use, for 1978.

ii. Efficacy and Suitability of Alternatives

Based on efficacy and other performance characteristics, inorganic arsenical-treated wood is suitable for most end-uses of lumber, timber and plywood. Inorganic arsenical-treated wood is clean, odorless, paintable, easy to handle, harmless to plants and durable compared to either penta- or creosote-treated wood. Inorganic arsenical wood preservatives are used for treating wood for uses such as patios, decks, playground equipment, cooling towers, greenhouses, horticultural nurseries and all weather wood foundations (AWWF). These uses comprise the bulk of the market for treated lumber, timber and plywood.

Penta- and creosote-treated lumber, timber and plywood have limited uses due to odor, objectionable vapors and oily, unpaintable surfaces. Penta in heavy oil and creosote are not suitable for treatment of wood used in decks, patios, playground equipment, stadium seats, agricultural wood uses, greenhouses, horticultural nurseries, cooling towers and boat hulls. However, penta in light oil or volatile solvents, such as liquified petroleum gas (Cellon® process) or methylene chloride (Dow process), is suitable for applications where retention of natural color and a paintable surface of the wood is necessary. Although the wood treatment industry has a limited capacity for utilizing volatile solvents, many plants can treat wood with penta in light oil solvents.

Creosote-treated wood is used for the interior use of industrial block flooring to protect the wood from mechanical as well as physical deterioration. Creosote is the only wood preservative which improves the dimensional stability of the wood block and reacts with the mastic to help bond the wood block to the concrete subflooring. Neither penta nor inorganic arsenical-treated wood is satisfactory for this use.

Creosote applications are also preferred where treated wood is subjected to a high volume of heavy traffic (e.g., crossing planks and decking for bridges, loading docks, wharves and piers) because of the protection from weathering and abrasion that it imparts to the wood. Penta in P9 oil also has these protective qualities (except for marine applications) and can be substituted for creosote for these uses; inorganic arsenicals are also an alternative for these use patterns except under conditions of high mechanical stress (e.g., mechanical driving), due to the brittleness imparted by the inorganic arsenical treatment.

Creosote-treated wood is also preferred for industrial applications in high acid environments due to creosote's high resistance to acids. Penta in heavy oil ranks second to creosote in this regard, with inorganic arsenicals having no acid resistance.

iii. Impacts of Cancellation

Due to the complexity of end-uses of treated lumber, timber and plywood in treated wood products and the wide cost range of the products (e.g., bridges, picnic tables, pole barns, etc.) in this use category, the total economic impact of cancellation or replacement cost of treated wood could not be estimated for the various scenarios. Economic impacts were determined only on the basis of changes in pesticide cost for treating lumber and timbers and the additional capital investment for equipment changes needed when converting from one preservative treatment system to another. These impacts do not reflect the total cancellation of the three major wood preservatives for this use category, but merely represents the types of cost attributable to each cancellation scenario.

Most creosote-treated wood in this use category could be replaced with either penta- or inorganic arsenical-treated wood except for industrial block flooring for which there is no substitute preservative. Table III-12 shows the economic impact on the preservative cost of cancelling either creosote, penta or both. If creosote were cancelled, penta or inorganic arsenicals would be utilized in the treatment of timbers. The cancellation of creosote could increase the volume of penta- or inorganic arsenical-treated timbers to 25.4 million and 79.1 million cubic feet, respectively. Some 700,000 cubic feet of wood products presumably would not be treated. The preservative cost would decline an estimated $11 million in this situation (Scenario II). If penta were cancelled and the inorganic arsenicals and creosote became the agents of choice for preservative treatments, the preservative cost would decline to an estimated $5 million (Scenario III) from the 1978 actual situation. However, if both penta and creosote were cancelled for treatment of lumber and timber, about 100 million cubic feet of wood would be treated with inorganic arsenicals and the remaining 700,000 cubic feet of industrial block flooring and 4.2 million cubic feet of transportation lumber would not be treated. The preservative cost for this situation would decline an estimated $20 million (Scenario IV) from the 1978 actual situation.

TABLE III-12 Alternative Scenarios for Estimated Consumption of Preservatives and Cost of Preservatives for Lumber and Timbers, 1978

Preservative	Volume (cubic feet)	Quantity of Preservatives (pounds)	Cost of Preservatives[a] (dollars)
	1,000		
Scenario I: 1978 Actual Situation			
Creosote	10,780	184,821	15,340
Penta	21,209	9,883	15,866
CCA/ACA	73,318	34,985	34,985
Total	105,307	229,689	66,191
Scenario II: Cancel Creosote and Shift to Penta and Arsenicals[b]			
Creosote	0	0	0
Penta	25,467	12,439	18,576
CCA/ACA	79,140	36,440	36,440
Not treated	700	-	-
Total	105,307	48,879	55,016
Scenario III: Cancel Penta and Shift to Arsenaicls			
Cresote	10,780	184,821	15,340
Penta	0	0	0
CCA/ACA	94,527	45,165	45,165
Total	105,307	229,986	60,505
Scenario IV: Cancel Creosote and Penta and Shift to Arsenicals			
Creosote	0	0	0
Penta	0	0	0
CCA/ACA	100,349	46,620	46,620
Not Treated	4,958[c]	0	-
Total	105,307	46,620	46,620

a. Cost of preservatives based on prices given in Table III-6.

b. Transportation uses shifted to penta, all others to inorganic arsenicals except industrial block flooring which could not be treated with penta or inorganic arsenicals.

c. Assumes that 700,000 cubic feet of industrial block flooring and 4,258 cubic feet of transportation lumber that is currently treated with creosote would not be treated with inorganic arsenicals.

TABLE III-13 Additional Capital Investment Required for Alternative Lumber Treatment Scenarios, 1978

Scenario	Equipment Changes Required[a]	Capital Investment Required
I	None	0
II	Convert 17 cylinders from creosote to penta or arsenicals at $25,000 each and build 10 kilns at $200,000 each	$2,425,000
III	Convert 36 cylinders from penta to arsenicals at $25,000 each and build 21 kilns at $200,000 each	$5,100,000
IV	Convert 45 cylinders from creosote and penta to arsenicals at $25,000 each and build 27 kilns at $200,000 each	$6,525,000

a. Assumes 600,000 cubic feet per cylinder per year and 1,000,000 cubic feet softwood per high temperature kiln per year.

TABLE III-14 Cost Effects of Required Capital Investments for Lumber

Scenario	Cost Effect of Additional Investment[a]	Cost Effect of 50% Increase in Preservative Cost	Combined Cost Effect
I	-	-	0
II	$ 533,500	$27,508,000	$28,041,500
III	1,122,000	22,582,500	23,704,500
IV	1,435,500	23,310,000	24,745,500

a. First year effect are based on amortizing investments over 10 years and 12% interest.

The additional capital investment for equipment changes required by the cancellation of creosote, penta or both for treatment of lumber, timber, and plywood are shown in Table III-13. The estimated additional capital investment ranges for a 10 year time period from $2.43 million (cancellation of creosote, Scenario II) to $6.53 million (cancellation of creosote and penta, Scenario IV). The first year cost effect of additional capital investment ranges from $533,500 (Scenario II) to $1.44 million (Scenario IV) as shown in Table III-14. Cost increases ranging from $22.6 million (Scenario III) to $27.5 million (Scenario II) would result from the 50% preservative price increase attributable to increased demand. The combined first year additional capital investment and a 50% price increase in preservative cost would result in increased costs ranging from $23.7 million (Scenario III) to $28 million (Scenario II). The net impact for the cancellation scenario under consideration ranges from approximately $5 million (Scenario IV) to approximately $18 million (Scenario III).

The cancellation of either creosote or penta would result in no expected major adverse economic impacts since inorganic arsenicals are the primary wood preservative used for lumber, timber and plywood. However, cancelling inorganic arsenicals would result in large adverse economic impacts and significant losses because penta and creosote are not generally acceptable substitutes and the costs of these alternatives are higher than those of the inorganic arsenicals. However, the Agency has limited information on the economic impacts of cancellation for some end-uses of inorganic arsenical-treated lumber used in home construction.

In a preliminary briefing given by the Mitre Corporation (EPA contract 68-01-5964, 1980; a final report is expected in January, 1981), the economic impact of cancelling inorganic arsenical application to lumber for use in home construction was analyzed for the end-uses of all weather wood foundation (AWWF), plates and sills, and structural framing. There are about 10,000 homes built annually with AWWF (about 2,400 board feet of ACA- and/or CCA-treated lumber per home), about 750,000 homes with plates and sills (about 220 board feet of ACA- and CCA-treated lumber per home) and about 8,000 homes with structural framing (about 10,000 board feet of CCA-treated lumber per home). Most of the AWWF homes are located in the northern United States, homes which have treated plates and sills are found in southern United States on slab foundations and the structural framing homes are located in Hawaii only. About 1% of the home foundations used treated wood or masonry and 99% used concrete.

If AWWF were cancelled, the most likely substitutes would be concrete and masonry foundations. The AWWF costs are likely to be lower than the concrete and masonry foundations in rural, isolated areas in the northern United States, but the concrete and masonry foundations are likely to be lower or equal in cost to those for AWWF in urban areas. In 1969, the costs for an AWWF was $1,973 compared to $2,238 for a masonry foundation, or an increase of about $265 per home (National Association of Home Builders Foundation, Inc., 1969). However, in 1976 the cost of an AWWF was $2,533 compared to $2,225 for poured concrete (a decline of about $308 per home) and $2,428 for masonry, or a decline of about $105 per home (National Ready Mixed Concrete Association, 1976).

If inorganic arsenical were cancelled for use of treating wood plates and sills, the most likely substitute would be steel plates and sills. The use of steel plates and sills for home construction instead of treated wood would result in no additonal cost. If inorganic arsenical were cancelled for use of treating wood structural framing, the most likely substitutes would be concrete, masonary and steel framing. The cost of these substitutes are similar to that of treated wood.

c. Pilings

i. Usage and Identification of Use Category

An estimated 12.09 million cubic feet of pilings (3.7% of all treated wood) were treated with preservatives in 1978. The distribution of pilings (including marine and foundation pilings) according to the type of preservative used was: creosote, 9,993,000 cubic feet (82.7%); penta, 1,154,000 cubic feet (9.5%); and inorganic arsenicals, 943,000 cubic feet

(7.8%). The estimated 1978 distribution of the 4,352,400 cubic feet of marine pilings by preservative type was: creosote, 3,977,223 cubic feet; penta, zero cubic feet; and inorganic arsenicals, 375,177 cubic feet. The estimated 1978 distribution of the 7,737,600 cubic feet of foundation pilings by preservative type was: creosote, 6,015,777 cubic feet; penta, 1,154,000 cubic feet; and inorganic arsenicals, 567,823 cubic feet (USDA-States-EPA, 1980).

While marine pilings accounted for an estimated 36% of treated pilings in 1978, they consumed more than 49% of the total cost of preservatives used to treat pilings. The total expenditure for preservatives to treat pilings in 1978 was estimated as $16.5 million. The service life (50 years) of the treated wood for the three wood preservatives is considered to be the same.

ii. Impacts of Cancelling Wood Preservatives

The quantity of preservatives which would be used and the changes in the estimated cost of treated pilings for different cancellation scenarios are presented in Table III-15*. Inorganic arsenicals could serve as an alternative for creosote in marine and foundation uses even though the brittleness imparted to pilings by inorganic arsenicals results in some breakage of pilings during shipping and mechanical driving. The breakage of the pilings treated with CCA is not expected to exceed 5%.

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* The scenario numbers are not consistent from use category to use category. For each use pattern, the scenarios are detailed in the accompanying tables.

The cancellation of creosote would result in the substitution of CCA-treated marine pilings (penta is not used or recommended for marine pilings) and would require an additional 9,943,058 pounds of CCA. This shift to inorganic arsenical treatment would not increase the price of treated pilings since the price and service life of the inorganic arsenical-treated pilings are essentially the same for both types of marine piling. The price of inorganic arsenical-treated foundation pilings is about $0.30 less per cubic foot than creosote pilings. Such a price differential would result in a treatment savings of about $1.8 million annually if foundation pilings were treated with inorganic arsenicals instead of creosote.

If creosote were cancelled for all piling uses, penta would most likely be used to treat foundation pilings and inorganic arsenicals would replace creosote for the marine pilings use. Under this scenario, an additional 3,609,466 pounds of penta (plus 152,213 barrels of #2 fuel oil for solvent) and 9,970,000 pounds of inorganic arsenicals would be required. The preservative costs would increase from $16.6 million (Scenario I) to $18.9 million (Scenario II), or about a 12% increase.

TABLE III-15 Pilings: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Pilings by Type of Preservative, 1978

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative (Dollars)	Cost of Pilings[a] (Dollars)
	- - - - - -	- - - - - - 1,000	- - - - - -	- - - - - -
Scenario I: 1978 Actual Situation				
Creosote	9,993	151,733	13,959	66,130
Penta	1,154	692	1,224	7,086
CCA/ACA	943	1,392	1,392	6,070
Total	12,090	153,818	16,575	79,286
Scenario II: Cancel Creosote and Shift Foundation to Penta and Marine to Arsenicals				
Creosote	0	0	0	0
Penta	7,170	4,302	7,607	44,022
CCA/ACA	4,920	11,335	11,335	35,263
Total	12,090	15,637	18,942	79,285
Scenario III: Cancel Creosote and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	1,154	692	1,224	7,085
CCA/ACA	10,936	17,465	17,465	70,405
Total	12,090	18,157	18,689	77,480
Scenario IV: Cancel Creosote and Penta and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	0	0	0	0
CCA/ACA	12,090	17,071	17,071	77,134
Total	12,090	17,071	17,071	77,134
Scenario V: Cancel Penta and Shift to Creosote				
Creosote	11,147	165,581	15,233	73,215
Penta	0	0	0	0
CCA/ACA	943	1,342	1,392	6,098
Total	12,090	166,923	16,625	79,313

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TABLE III-15 Pilings: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Pilings by Type of Preservative, 1978 (cont'd)

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative (Dollars)	Cost of Pilings[a] (Dollars)
	- - - - - - -	- - - - - 1,000	- - - - - - -	- - - - - - -
Scenario VI: Cancel Penta and Shift to Arsenicals				
Creosote	9,993	151,734	13,959	66,129
Penta	0	0	0	0
CCA/ACA	2,097	2,315	2,315	12,809
Total	12,090	154,049	16,274	78,938

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a. Marine pilings are $7.43 per cubic foot (Compton, 1979) and foundation pilings are $6.14 per cubic foot (Engineering News Record, 1979).

On the other hand, if penta were cancelled and inorganic arsenical treatment substituted for all penta treatment, an additional 923,000 pounds of inorganic arsenicals would be required to treat these foundation pilings under this scenario. The preservative cost would decline from $16.6 (Scenario I) million to $16.3 million (Scenario VI), or about <1% decline for this scenario.

The additional capital investment required for the various scenarios are presented in Table III-16. The necessary additional capital investment would range from $50,000 (Scenario V) to $7.45 million (Scenario IV).

The cost effect of the estimated 50% increase in preservative prices resulting from the increased demand for preservatives brought about by the various cancellation scenarios is presented in Table III-17; this cost ranges from $8.1 million (Scenario VI) to $9.47 million (Scenario II). The adjusted cost of treated pilings for these scenarios, which includes the additional capital investment and an estimated 50% increase in preservative cost varies from $87.3 million (Scenario IV) to $89.4 million (Scenario II) compared to $79.29 million (Scenario I). This reflects a 10% to 13% increase over the 1978 cost.

TABLE III-16 Additional Capital Investment Required for Alternative Pilings Treatment Scenarios, 1978

Scenario	Equipment Changes Required[a]	Capital Investment Required
I	None	0
II	Convert 10 cylinders from creosote to penta at $25,000 each and convert 6 cylinders to arsenicals at $25,000 and 20 kilns at $125,000 each	$2,900,000
III	Convert 16 cylinders from creosote to arsenicals at $25,000 each and 50 kilns at $125,000 each	$6,650,000
IV	Convert 18 cylinders from creosote and penta to arsenicals at $25,000 each and 56 kilns at $125,000 each	$7,450,000
V	Convert 2 cylinders from penta to creosote at $25,000 each	$50,000
VI	Convert 2 cylinders from penta to arsenicals at $25,000 each and 2 kilns at $125,000 each	$300,000

a. Assumes 200,000 cubic feet per kiln per year (5 days per charge).

TABLE III-17 Pilings: Cost Effects of Required Capital Investment and a 50% Increase in Preservative Prices, 1978

	Scenarios		
	I	II	III
Cost effect of additional investment[a]	0	$ 638,000	1,463,000
Cost effect of 50% 50% increase in preservative prices	0	9,471,195	9,344,797
Combined cost effect	0	10,109,195	10,807,797
Adjusted cost of treated piling after capital and price	$79,285,132	89,394,327	88,288,197
Ratio of treated pilings under alternative scenario to actual 1978 cost	1.000	1.128	1.114

a. First year cost: amortized over 10 years at 12%.

TABLE III-17 Pilings: Cost Effects of Required Capital Investment and a 50% Increase in Preservative Prices, 1978 (continued)

	Scenarios		
	IV	V	VI
Cost effect of additional investment[a]	$ 1,639,000	11,000	66,000
Cost effect of 50% 50% increase in preservative prices	8,535,540	8,312,000	8,137,000
Combined Cost effect	10,174,540	8,323,000	8,313,000
Adjusted cost of treated pilings after capital and price	87,308,740	87,608,000	88,252,000
Ratio of treated pilings under alternative scenario to actual 1978 cost	1.101	1.105	1.113

a. First year cost: amortized over 10 years at 12%.

iii. Alternatives to Treated Wood Pilings: Concrete and Steel

Both concrete and steel can provide technically acceptable alternative materials for pilings in foundation uses. However, steel would be subject to corrosion in highly acidic soils or in marine environments (Fuller et al., 1977). The materials cost of both concrete and steel piles, as well as installation costs, are higher than treated wood piles on a one for one basis (Smith, 1980; Andrews, 1980). However, the total cost of pilings at a given site may not increase significantly when concrete or steel pilings are substituted for treated wood pilings, if opportunities exist for assigning heavier loads to individual piles. In the case of residential and small commercial buildings where loads are relatively low, concrete or steel will usually be much higher in cost than treated wood piles.

Table III-18 provides a comparison of the average annual costs of installed treated wood, concrete and steel pilings. The total installed average annual cost of pilings is estimated to be $258.1 million for concrete piles and $322.7 million for steel piles compared to $193.6 million for treated wood piles. However, concrete or steel piles may be assigned heavier loads than those previously assigned to treated wood piles. Assuming that one concrete or steel pile replaces 1.5 treated piles, the average annual installed cost of concrete and steel piling would be $172.1 million for concrete (about an 11% decline) and $215.1 million for steel (about an 11% increase) compared to the $193.6 million for treated wood pilings.

TABLE III-18 Estimated Cost of Using Treated Wood Piles, Concrete Piles or Steel Piles in the United States, 1978

	Treated Wood	Concrete	
		A	B
Installed cost per pile (50 foot pile)[a]	$ 450	$ 600	$ 600
Service life (years)	50	50	50
Number of 50-foot pile equivalents installed per year	430,249[b]	430,249[b]	286,832[c]
Current total cost per year (million dollars)	193.6	258.1	172.1
Present value of future cost stream (millions of dollars)[d]	1,935.98	2,581.31	1,170.87
Annualized cost (millions of dollars)[e]	193.6	258.1	172.1

a. Based on estimated installed costs for 50 foot pilings installed on a site with 400 piles required (Smith, 1980).

b. Assumes 28 cubic feet per average 50 foot pile and 12,090,000 cubic feet of treated wood piles in the United States.

c. Assumes one concrete or steel pile will replace 1.5 treated wood piles.

d. Present value = Total cost stream for 100 years discounted at 10%.

e. Average annual cost $= \frac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

TABLE III-18 Estimated Cost of Using Treated Wood Piles, Concrete Piles or Steel Piles in the United States, 1978 (continued)

	Treated Wood	Steel	
		A	B
Installed cost per pile (50 foot pile)[a]	$ 450	$ 750	$ 750
Service life (years)	50	50	50
Number of 50-foot pile equivalents installed per year	430,249[b]	430,249[b]	286,832[c]
Current total cost per year (million dollars)	193.6	322.7	215.1
Present value of future cost stream (millions of dollars)[d]	1,935.98	3,226.63	2,150.85
Annualized cost (millions of dollars)[e]	193.6	322.7	215.1

a. Based on estimated installed costs for 50 foot pilings installed on a site with 400 piles required (Smith, 1980).

b. Assumes 28 cubic feet per average 50 foot pile and 12,090,000 cubic feet of treated wood piles in the United States.

c. Assumes one concrete or steel pile will replace 1.5 treated wood piles.

d. Present value = Total cost stream for 100 years discounted at 10%.

e. Average annual cost $= \dfrac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

d. Posts.

i. Usage and Identification of Use Category

In 1978, an estimated 20 million cubic feet of posts were treated with preservatives (USDA-States-EPA, 1980). Treated wood posts include such uses as fences for farms, yards, patios, highway guardrails and highway signposts; farm fence posts account for the largest proportion of treated posts use. The average service life of untreated fence post is only 3.3 years compared with 38 years for creosote- or inorganic arsenical-treated posts (ACA) and 33 years for posts treated with penta (Josephson, 1979).

The distribution of fence posts by type of treatment in 1978 was: creosote, 4,584,000 cubic feet (22.9%); penta, 10,983,000 cubic feet (54.8%); and inorganic arsenicals, 4,461,000 cubic feet (22.3%).

The quantity of preservatives used in 1978 to treat fence posts was 27.5 million pounds of creosote, 3.3 million pounds of penta, and 1.78 million pounds of inorganic arsenicals with a total preservative cost of $10.1 million. The total cost of treated wood posts in 1978 was $66.1 million.

ii. Impacts of Cancelling Wood Preservatives

The economic impacts associated with cancelling one or more of the three wood preservatives for treating wood posts are shown in Table III-19 (Scenarios 1 through VIII). The difference in chemical costs for the various scenarios would range from a decrease of $2.1 million (Scenario VIII) to an increase of $700,000 (Scenario VI) from the 1978 cost of $10.1 million (Scenario I). The estimated cost of treated posts for the scenarios under consideration varies from $62.5 million (Scenario VIII) to $67.6 million (Scenario VI) compared to $66.1 million (Scenario I) for the 1978 cost of treated posts. Additional capital investment for equipment changes would vary from $200,000 (Scenario II) to $10.38 million (Scenario VIII), as shown in Table III-20. The potential impacts of additional capital investment and a 50% increase in preservative prices due to increased demand for the preservatives remaining on the market are shown in Table III-21. The addition of capital investment costs and the 50% increase in preservative costs (Table III-21) to the estimated cost of treated posts (Table III-20), gives the adjusted cost of treated posts for each scenario. The adjusted cost of treated posts for these scenarios would range from $66.6 million (Scenario III) to $72.0 million (Scenario IV) compared to the 1978 cost for treated wood posts of $66.9 million (Scenario I).

TABLE III-19 Posts: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Posts by Type of Perservative, 1978

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Posts[b] (Dollars)
	1,000			
Scenario I: 1978 Actual Situation				
Creosote	4,584	27,504	2,530	15,815
Penta	10,983	3,295	5,821	36,354
CCA/ACA	4,461	1,784	1,784	13,918
Total	20,028	32,583	10,135	66,087
Scenario II: Cancel Creosote and Shift to Penta				
Creosote	0	0	0	0
Penta	15,567	4,670	8,251	51,527
CCA/ACA	4,461	1,784	1,784	13,918
Total	20,028	6,454	10,035	65,445
Scenario III: Cancel Creosote and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	10,983	3,295	5,821	36,354
CCA/ACA	9,045	3,618	3,618	28,220
Total	20,028	6,913	9,439	64,574
Scenario IV: Cancel Penta and Shift to Creosote				
Creosote	15,567	93,402	8,593	53,706
Penta	0	0	0	0
CCA/ACA	4,461	1,784	1,784	13,918
Total	20,028	95,186	10,377	67,624
Scenario V: Cancel Penta and Shift to Arsenicals				
Creosote	4,584	27,504	2,530	15,815
Penta	0	0	0	0
CCA/ACA	15,444	6,178	6,178	48,185
Total	20,028	33,682	8,708	64,000
Scenario VI: Cancel Arsenicals and Shift to Creosote				
Creosote	9,045	54,207	4,993	31,205
Penta	10,983	3,295	5,821	36,354
CCA/ACA	0	0	0	0
Total	20,028	57,565	10,814	67,559

TABLE III-19 Posts: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Posts by Type of Preservative, 1978 (cont'd)

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Posts[b] (Dollars)
	- - - - - - - - - - - -	- - - - 1,000 - - - -	- - - - - - - - - - - -	- - - - - - - - - - - -
Scenario VII: Cancel Arsenicals and Shift to Penta				
Creosote	4,584	27,504	2,530	15,815
Penta	15,444	4,633	8,185	51,120
CCA/ACA	0	0	0	0
Total	20,028	32,137	10,715	66,935
Scenario VIII: Cancel Creosote and Penta and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	0	0	0	0
CCA/ACA	20,028	8,011	8,011	62,487
Total	20,028	8,011	8,011	62,487

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a. Based on retention per cubic foot and cost given in Table III-6 and Table III-7.

b. Cost per cubic foot f.o.b. at plant: creosote $3.45, penta $3.31, and CCA $3.12 (Stevens, 1979).

TABLE III-20 Additional Capital Investment Required for Alternative Post Treatment Scenarios, 1978

Scenario	Equipment Changes Required[a]	Capital Investment Required
I	None	0
II	Convert 8 cylinders from creosote to penta at $25,000 each	$200,000
III	Convert 8 cylinders from creosote to arsenicals at $25,000 each and 23 kilns at $125,000 each each	$3,075,000
IV	Convert 18 cylinders from penta to creosote at $25,000 each	$450,000
V	Convert 18 cylinders from penta to arsenicals at $25,000 each and build 55 kilns at $125,000 each	$7,325,000
VI	Convert 8 cylinders from arsenicals to creosote at $200,000 each	$1,600,000
VII	Convert 8 cylinders from arsenicals to penta at $200,000 each	$1,600,000
VIII	Convert 25 cylinders from penta and creosote to arsenicals at $25,000 each and build 78 kilns at $125,000 each	$10,375,000

a. Assumes 200,000 cubic feet per kiln per year.

TABLE III-21 Posts Cost Effects of Required Capital Investment and a 50% Increase in Preservative Prices, 1978

	Scenarios			
	I	II	III	IV
Cost effect of additional investment[a]	0	44,000	264,000	99,000
Cost effect of 50% increase in preservative prices	0	4,125,255	1,809,000	4,296,000
Combined effect	0	4,169,225	2,073,000	4,395,000
Adjusted cost of treated posts after captial and price increase	$66,935,000	69,614,255	66,647,000	72,019,000
Ratio of cost of treated posts under alternative scenario to actual 1978 cost	1.000	1.040	0.996	1.076

a. First year cost: amortized over 10 years at 12%.

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TABLE III-21 Posts Cost Effects of Required Capital Investment and a 50% Increase in Preservative Prices, 1978 (continued)

	Scenarios			
	V	VI	VII	VIII
Cost effect of additional investment[a]	594,000	352,000	352,000	825,000
Cost effect of 50% increase in preservative prices	3,088,800	2,496,000	4,092,660	4,005,600
Combined effect	3,682,800	3,376,000	4,444,660	4,830,600
Adjusted cost of treated posts after captial and price increase	$67,682,800	70,935,000	71,379,660	67,317,600
Ratio of cost of treated posts under alternative scenario to actual 1978 cost	1.011	1.060	1.066	1.006

a. First year cost: amortized over 10 years at 12%.

iii. Alternative Fence Post Materials

If all three major wood preservatives were cancelled, steel or concrete posts would be the most likely alternative materials for fence post use. T-type steel posts, which serve as substitutes for wood posts in farm fences, are priced competitively with treated posts. Thus, substitution of steel posts in many farm applications would not necessarily lead to much higher fencing costs. Concrete posts would be more expensive than steel and probably would not be substituted in most farm situations.

e. Crossarms

i. Usage and Identification of Use Category

Crossarms are the cross members of assembled utility poles. An estimated 1,685,000 cubic feet of crossarms (0.5% of total treated wood) were treated with wood preservatives in 1978. The distribution of crossarms by preservative treatments was: creosote, 41,000 cubic feet (2.5%); penta, 1,615,000 cubic feet (95.8%); and inorganic arsenicals, 29,000 cubic feet (1.7%).

The consumption of preservatives for treating crossarms in 1978 was 389,000 pounds of creosote, 646,000 pounds of penta plus 1,411,267 gallons of petroleum solvent (27,173 barrels of oil), and 11,600 pounds of inorganic arsenicals with a total estimated preservative cost of $1.18 million. The 1978 cost of the treated crossarms was estimated as $14.86 million. The service lives of crossarms treated with the three major wood preservatives are considered to be equivalent (40 years).

ii. Impacts of Cancellation

Since penta accounts for nearly 96% of treated crossarms, its cancellation would result in a major economic impact (e.g., for converting to other preservative treatments) on the crossarm treatment industry. Table III-22 shows the changes in preservative costs for various cancellation scenarios and can be used to compare the changes in the cost of treated crossarms for each scenario. A shift from penta to creosote (Scenario II) would result in a $47,000 annual increase in chemical costs and an increase of $614,000 in the cost of treated crossarms. If penta were cancelled and inorganic arsenicals were substituted for crossarms treatment (Scenario III), the preservative cost would decline about $496,000 annually resulting in a $791,000 annual decline in the estimated cost of treated crossarms compared to the 1978 cost. Although less than 2% of crossarms were treated with inorganic arsenicals in 1978, inorganic arsenical-treated crossarms are gaining acceptance among some utility companies such as Virginia Electric Power Company (VEPCO) in Virginia (Farmer, 1979).

TABLE III-22 Crossarms: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Crossarms by Type of Preservative, 1978

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Crossarms[b] (Dollars)
	1,000			
Scenario I: 1978 Actual Situation				
Creosote	41	398	30	377
Penta	1,615	646	1,142	14,244
CCA/ACA	29	12	12	242
Total	1,685	1,056	1,184	14,863
Scenario II: Cancel Penta and Shift to Creosote				
Creosote	1,656	13,248	1,219	15,235
Penta	0	0	0	0
CCA/ACA	29	12	12	242
Total	1,685	13,260	1,231	15,477
Scenario III: Cancel Penta and Shift to Arsenicals				
Creosote	41	328	30	377
Penta	0	0	0	0
CCA/ACA	1,644	658	658	13,695
Total	1,685	986	688	14,072
Scenario IV: Cancel Creosote and Arsenicals and Shift to Penta				
Creosote	0	0	0	0
Penta	1,685	674	1,191	14,682
CCA/ACA	0	0	0	0
Total	1,685	674	1,191	14,682
Scenario V: Cancel Creosote and Penta and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	0	0	0	0
CCA/ACA	1,685	674	674	14,036
Total	1,685	674	674	14,036
Scenario VI: Cancel Creosote and Shift to Penta				
Creosote	0	0	0	0
Penta	1,656	662	1,171	14,606
CCA/ACA	29	12	12	242
Total	1,685	674	1,183	14,848

TABLE III-22 Crossarms: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Crossarms by Type of Preservative, 1978 (cont'd)

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Crossarms[b] (Dollars)
	- - - - - - - - - - - - 1,000	- - - - - - - - - - - - - - -		
Scenario VII: Cancel Creosote and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	1,615	646	1,142	14,244
CCA/ACA	70	28	49	583
Total	1,685	674	1,191	14,827

a. Retention per cubic foot: creosote 8 pounds, penta 0.4 pounds, and arsenicals 0.4 pounds.

b. Cost per cubic foot f.o.b. at plant: creosote $9.20, penta $8.82, and CCA $8.33 (Colemen, 1979).

TABLE III-23 Crossarms: Cost Effects of Required Capital Investment and a 50% Increase in Preservative Prices, 1978

	Scenarios		
	I	II	III
Cost effect of additional investment[a]	0	$ 16,500[b]	236,500[c]
Cost effect of 50% 50% increase in preservative prices	0	609,500	328,800
Combined cost effect	0	626,000	565,300
Adjusted cost of treated crossarms after increase	$14,863,070	16,103,000	14,637,020
Ratio of treated crossarms under alternative scenario to actual 1978 cost	1.000	1.083	0.985

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a. First year cost: amortized over 10 years at 12%.

b. Convert 3 cylinders to creosote at $25,000 each.

c. Convert 3 cylinders to arsenicals and construct 8 drying kilns at $125,000 each.

The first year cost effect of additional capital investment required for plant conversion resulting from the various cancellation scenarios is given in Table III-23 and ranges for the penta cancellation scenarios from $16,500 (Scenario II) to $236,500 (Scenario III). If preservative prices were to increase 50% as a result of increased demand, the cost effect would range from $328,800 (Scenario III) to $610,000 (Scenario II). For each scenario, the combination of the additional capital investment costs and the 50% increase in preservative costs (Table III-23) with the estimated cost of treated crossarms (Table III-22) gives the adjusted cost of treated crossarms. The adjusted cost ranges from an increase of $1.24 million (Scenario II) to a decrease of $226,000 (Scenario III).

iii. Non-wood Alternatives

Steel crossarms are used by some utility companies (e.g., VEPCO). A distribution steel crossarm that is competitive with treated crossarms has been used by VEPCO, but has limited usage since steel crossarms are not a complete substitute for treated wood crossarms (Farmer, 1979).

f. Poles

i. Usage and Identification of Use Category

Treated poles are the principal structural support elements in the 4.52 million miles of the electric distribution system and the estimated additional 640,000 miles of electrical transmission lines in the United States. Treated poles are also used to support telephone lines, as light standards, and for construction uses in residential and other buildings. The USDA-States-EPA Assessment Team (1980) estimated that, in 1978, 64.2 million cubic feet of wood (2.86 million treated poles) were treated and represented about 19% of all wood treated with preservatives. The volume distribution of preservatives for treated poles in 1978 was: penta, 65.3%; creosote, 28.4%; and inorganic arsenicals, 6.3% of the total treated pole volume. The users of the 125,539,000 treated utility poles currently in service in the United States are electric utilities (94,139,000 poles), who purchase about 92.8% of total volume of treated poles produced annually and telephone, railroads, industry and others such as farm, commercial and residential (31,400,000 utility poles), who purchase the remaining 7.2% of treated poles produced annually.

In addition to the treated poles which carry utility lines, an estimated 2.06 million treated poles are used annually in farm, commercial, and residential construction. Treated poles used for construction purposes (e.g., pole barns) are considered to be similar in use pattern to treated timbers and are included in the use category of lumber, timber and plywood.

Virtually all of the utility poles are produced in two regions of the United States that are contiguous with the natural ranges of the Southern pine and Douglas fir, the tree species which account for more than 85% of total pole production. Seventyfive percent of annual pole production comes from the Southern Pine region, which extends from Maryland to East Texas. The Douglas fir region, which is centered in California, Oregon and Washington, produces about 10% and is responsible for most of the treated wood poles used in the United States that are longer than 70 feet.

ii. Impacts of Cancelling Wood Preservatives in Terms of Annual Costs

There are no viable chemical alternatives for the three major wood preservative agents for pole treatment, with the possible exception of copper naphthenate for certain limited uses. However, copper naphthenate is unsuitable for large-scale use in poles because it imparts a green, greasy surface to the poles, is unstable in the presence of moisture and causes corrosion of metals. The service life of inorganic arsenical-treated poles is assumed to be 50 years in this analysis; for penta- and creosote-treated poles, a service life of 35 years is assumed. However, the expected service life of treated poles varies in practice with the quality of preservative treatment and with the severity of the environmental conditions at the point of end-use. A recent survey of investor-owned electric companies revealed that all companies recorded an average service life of greater than 20 years for the treated poles in their systems (Electric World, 1979).

Table III-24 shows the changes in preservative costs and in the estimated cost of treated poles for various cancellation scenarios. The change in preservative costs varies from a decrease of $12.75 million (Scenario IV) where penta and creosote are cancelled to an increase of $963,000 (Scenario X) for the cancellation of penta and shift to creosote. The estimated treated pole costs would range from a decrease of $27.7 million (Scenario IV) to an increase of $10.8 million (Scenario VIII) under the scenarios considered in this analysis. Table III-25 presents the cost of the equipment changes required for conversion to the various alternatives. The additional capital investment for equipment changes required for the changes in preservative treatments ranges from $750,000 (Scenario II) to $39.9 millions (Scenario IV). The largest capital investments are required in those situations where the use of inorganic arsenicals would be increased.

The cost impact of additional capital investments and increased demand for preservatives is presented in Table III-26 for the various cancellation scenarios. The annual cost effect of a 50% cost increase in preservative prices varies from zero (Scenarios VI & VII) to $25.8 million (Scenario IX). The annual combined capital investment and estimated increase in preservative price ranges from $308,000 (Scenarios VI & VII) to $28 million (Scenario IV). The resultant adjusted cost of the treated poles for these scenarios ranges from $276.7 (Scenarios VI & VII) to $310.2 million (Scenario VIII) compared to the 1978 cost of treated poles of $274.8 million (Scenario I). Thus, the largest impact on adjusted treated pole cost would be an increase of about 13% ($36.5 million) for the cancellation of inorganic arsenicals and penta. However, the difference in installed per pole cost is likely to be relatively small since the preservative cost represents a small proportion of total installed pole cost.

iii. Alternatives Other than Wood

Although concrete, steel, aluminum and fiberglass poles have been suggested as alternatives for treated wood poles, price and technical considerations indicate that concrete and steel are the most likely alternatives for treated poles in the near future. Underground installation provides an additional alternative for distribution and transmission lines in urban areas or in new subdivisions as required by local regulations (e.g., municipal ordinance). Over 40% of new distribution lines were installed underground in 1978 (Electric World, 1979). Actual inground installation costs may be similar to above ground installation costs in new subdivisions, but inground installation may be several times more expensive than above ground installation in existing housing areas. If all three wood perservatives were cancelled, the lack of treated wood poles would probably encourage more underground installation in areas where such installations could compete with concrete or steel poles. The use of untreated poles is not feasible since effective pole life would be only 2 to 4 years.

TABLE III-24 Poles: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Poles by Type of Perservative, 1978

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Poles[b] (Dollars)
	- - - - - - - - - - - - -	1,000	- - - - - - - - - - - - - - -	
Scenario I: 1978 Actual Situation				
Creosote	18,237	164,133	15,100	81,155
Penta	41,905	18,857	33,734	178,096
CCA/ACA	4,038	2,423	2,423	15,546
Total	64,180	185,413	51,257	274,797
Scenario II: Cancel Creosote and Shift to Penta				
Creosote	0	0	0	0
Penta	60,142	27,064	48,414	255,603
CCA/ACA	4,038	2,423	2,423	15,546
Total	64,180	29,487	50,837	271,149
Scenario III: Cancel Creosote and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	41,905	18,857	33,733	178,096
CCA/ACA	22,275	13,365	13,365	85,758
Total	64,180	32,222	47,098	263,855
Scenario IV: Cancel Creosote and Penta and Shift to Arsenicals				
Creosote	0	0	0	0
Penta	0	0	0	0
CCA/ACA	64,180	38,507	38,507	247,089
Total	64,180	38,507	38,507	247,089
Scenario V: Cancel Penta and Shift to Arsenicals				
Creosote	18,237	164,133	15,100	81,154
Penta	0	0	0	0
CCA/ACA	45,943	27,566	27,566	175,881
Total	64,180	191,699	42,666	258,035
Scenario VI: Cancel Arsenicals and Shift to Penta				
Creosote	18,237	164,133	15,100	81,155
Penta	45,943	20,674	36,984	195,257
CCA/ACA	0	0	0	0
Total	64,180	184,807	52,084	276,412

TABLE III-24 Poles: Alternative Scenarios for Estimated Consumption of Preservatives, Cost of Preservatives, and Cost of Treated Poles by Type of Preservative, 1978 (cont'd)

	Volume (cubic feet)	Quantity of Preservative (Pounds)	Cost of Preservative[a] (Dollars)	Cost of Poles[b] (Dollars)
	- - - - - - - - - - - -	- 1,000 -	- - - - - - - - - - - -	- - - - -
Scenario VII: Cancel Arsenicals and Shift to Creosote				
Creosote	22,275	200,475	18,444	99,124
Penta	41,905	18,857	33,734	178,096
CCA/ACA	0	0	0	0
Total	64,180	219,332	52,178	277,220
Scenario VIII: Cancel Arsenicals and Penta and Shift to Creosote				
Creosote	64,180	557,611	51,300	285,596
Penta	0	0	0	0
CCA/ACA	0	0	0	0
Total	64,180	557,611	51,300	285,596
Scenario IX: Cancel Arsenicals and Creosote and Shift to Penta				
Creosote	0	0	0	0
Penta	64,180	28,881	51,664	272,760
CCA/ACA	0	0	0	0
Total	64,180	28,881	51,664	272,760
Scenario X: Cancel Penta and Shift to Creosote				
Creosote	60,142	541,278	49,797	267,632
Penta	0	0	0	0
CCA/ACA	4,038	2,423	2,423	15,546
Total	64,180	543,701	52,220	283,178

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a. Based on retention per cubic foot and cost given in Table III-6 and Table III-7.

b. Cost per cubic foot f.o.b. at plant: creosote $4.45, penta $4.25, and CCA $3.85 (Compton, 1979).

TABLE III-25 Additional Capital Investment Required for Alternative Pole Treatment Scenarios, 1978

Scenario	Equipment Changes Required[a]	Capital Investment Required
I	None	0
II	Convert 30 cylinders from creosote to penta at $25,000 each	$750,000
III	Convert 30 cylinders from creosote to arsenicals at $25,000 each and 91 kilns at $125,000 each	$12,125,000
IV	Convert 97 cylinders from creosote and penta to arsenicals at $25,000 each and 300 kilns at $125,000 each	$39,925,000
V	Convert 68 cylinders from penta to arsenicals at $25,000 each and 209 kilns at $125,000 each	$27,825,000
VI	Convert 7 cylinders from arsenicals to penta at $200,000 each	$1,400,000
VII	Convert 7 cylinders from arsenicals to creosote at $200,000 each	$1,400,000
VIII	Convert 7 cylinders from arsenicals to creosote at $200,000 each and convert 68 cylinders from penta to creosote at $25,000 each	$3,100,000
IX	Convert 7 cylinders from arsenicals to penta at $200,000 each and convert 30 cylinders from creosote to penta at $25,000 each	$2,150,000
X	Convert 68 cylinders from penta to creosote at $25,000 each	$1,700,000

[a] Assumes 137 poles per kiln charge or 2,740 cubic feet and 73 kiln charges per year (5 days per charge).

TABLE III-26 Poles: Cost Effects of Required Capital Investment and a 50% Increase of Preservative Prices, 1978

	Scenarios				
	I	II	III	IV	V
Cost effect of additional investment[a]	0	$ 165,000	2,667,500	8,783,500	6,121,500
Cost effect of 50% increase in preservative cost	0	24,372,155	6,682,500	19,253,700	13,782,900
Combined cost effect	0	24,372,155	9,350,000	28,037,200	19,904,400
Adjusted cost of treated poles after capital and price increase[b]	274,797,200	295,521,955	284,147,200	302,834,400	294,701,600
Ratio of cost of treated poles under new scenario to actual 1978 cost	1.000	1.075	1.034	1.102	1.07

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a. First year effect: Based on amortizing investment over 10 years and 12%.

b. Derived by adding combined cost effect to total cost of treated poles for each scenario given in Table III-24.

TABLE III-26 Poles: Cost Effects of Required Capital Investment and a 50% Increase of Preservative Prices, 1978 (continued)

	Scenarios				
	V	VI	VIII	IX	X
Cost effect of additional investment[a]	308,000	308,000	682,000	473,000	374,000
Cost effect of 50% increase in preservative cost	0[c]	0[c]	23,970,856	25,832,048	24,898,000
Combined cost effect	308,000	308,000	24,652,856	26,305,048	25,272,000
Adjusted cost of treated poles after capital and price increase[b]	276,720,400	276,720,400	310,249,406	299,065,798	308,448,000
Ratio of cost of treated poles under new scenario to actual 1978 cost	1.010	1.010	1.129	1.088	1.122

a. First year effect: Based on amortizing investment over 10 years and 12%.

b. Derived by adding combined cost effect to total value of treated poles for each scenario given in Table III-24.

c. Small volume of additional preservative is assumed to have no price effect.

The utility industry would probably continue to use treated wood poles if any one of the three preservatives were retained. If all three wood preservatives were cancelled, the utility industry would probably utilize a combination of steel and concrete poles and underground installation. The construction industry would probably switch from pole buildings to foundation supported buildings.

iv. Annualized Cost Impact on Distribution Pole System

The definition for "annualized" cost and the methodology employed for this cost determinations are presented in Section III.B.4, Methods and Assumptions. Table III-27 presents comparative cost estimates for the treated wood distribution pole system and potential alternative distribution systems based on 1978 use patterns. The 1978 total annualized cost for the treated pole system is estimated at $1.03 billion. The annualized cost would increase to $1.06 billion (or a $30 million increase) if all poles were treated with creosote and decline to $0.99 billion (or a $44 million decrease) if all poles were treated with inorganic arsenicals.

The use of concrete as an alternative to treated wood distribution wood poles would result in an annualized cost of $2.3 billion (an increase of $1,3 billion). A shift from treated wood poles to steel poles or towers would result in an annualized cost of $3.1 billion (an increase of $2.0 billion).

TABLE III-27 Estimated Costs of Treated Wood, Concrete, and Steel Poles or Towers in Utility Distribution Systems, 1978

Item	Current Mix of Treated Poles	Creosote-Treated Poles	Penta-Treated Poles
Installed cost per pole (dollars)[a]	350.80	355.00	350.00
Service life (year)	35	35	35
Poles in system (million)	118	118	118
Average number of poles installed per year to maintain the system	3,227,777	3,371,428	3,371,428
Present value of future cost of maintaining system (million dollars)[b]	10,335.45	10,663.45	10,513.26
Annualized cost of maintaining the system (million dollars)[c]	1,033.54	1,066.34	1,051.33
Annualized cost per pole (dollars)	8.76	9.04	8.91

a. Weighted average of data supplied by Edison Electric Institute (1979) and Rural Electric Administration (1979).

b. Assumes number of poles used per year will expand in equal increments during next ten years from current 2,418,500 poles to an average number required to maintain the system. Discount rate is 10%, system life is 100 years.

c. Average annual cost $= \frac{\text{Present value} \times (1+r)^n}{(1+r)^n - 1}$,where r = 10% and n = 100

TABLE III-27 Estimated Costs of Treated Wood, Concrete, and Steel Poles or Towers in Utility Distribution Systems, 1978 (continued)

Item	Inorganic Arsenical-Treated Poles	Concrete Poles	Steel Poles
Installed cost per pole (dollars)[a]	340.00	770.00	1,050.00
Service life (year)	50	35	50
Poles in system (million)	118	118	118
Average number of poles installed per year to maintain the system	2,360,000	3,371,428	2,360,000
Present value of future cost of miantaining system (million dollars)[b]	9,899.99[d]	23,129.17	30,573.50[d]
Annualized cost of maintaining the system (million dollars)[c]	989.99	2,312.92	3,057.35
Annualized cost per pole (dollars)	8.38	19.60	25.90

a. Weighted average of data supplied by Edison Electric Institute (1979) and Rural Electric Administration (1979).

b. Assumes number of poles used per year will expand in equal increments during next ten years from current 2,418,500 poles to an average number required to maintain the system. Discount rate is 10%, system life is 100 years.

c. Average annual cost $= \frac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

d. Assumes 3,371,428 poles per year for 35 years and 0 poles for 15 years.

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v. Annualized Cost Impact on Transmission Pole System

The cost impacts for replacing treated wood poles with steel or concrete for transmission poles is shown in Table III-28. Concrete and steel poles become more competitive with treated wood poles as the size of the transmission structure increases. Between 70% and 90% of new transmission lines now being constructed are supported by steel towers. For example, in 1978 a new transmission 161 KV line structure cost about $100,000 per mile with wood (H-frame) construction and about $135,000 using steel towers (Wilhoirte, 1979). Thus, the cost of a steel supported line was about 1.35 times the cost of treated pole supported lines.

The annualized costs of treated wood poles and non-wood alternatives for transmission lines are summarized in Table III-28. The use of creosote for all transmission poles would result in a annualized cost for the system of $354 million (an increase of $12 million). If all transmission poles were treated with inorganic arsenicals, the annualized cost of the system would be $334 million (a decrease of $8 million).

TABLE III-28 Estimated Costs of Treated Wood, Concrete, and Steel Poles or Towers in Utility Transmission Systems, 1978

Item	Current Mix of Treated Poles	Creosote-Treated Poles	Penta-Treated Poles
Installed cost per pole (dollars)[b]	1,478	1,491	1,476
Service life (year)	36	35	35
Poles in system (million)	8.33	8.33	8.33
Average number of poles installed per year to maintain the system	231,388	238,000	238,000
Present value of future cost of maintaining system (million dollars)[b]	3,420.49	3,549.17	3,513.47
Annualized cost of maintaining the system (million dollars)[c]	342.05	354.92	351.35
Annualized cost per pole (dollars)	41.06	42.60	42.18

a. Weighted average of data supplied by Edison Electric Institute (1979) and Rural Electric Administration (1979).

b. Present value equals the total cost stream for 100 years discounted at 10%.

c. Average annual cost $= \dfrac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1}$,where r = 10% and n = 100

If all three wood preservatives were cancelled and utility companies utilize concrete transmission poles, the annualized cost would be $913 million (an increase of $571 million). If the utility companies substitute steel poles for the wood pole towers, annualized costs would be $1,093 million (an increase of $751 million). Other treated pole materials such as aluminum or fiberglass were not analyzed as alternatives since they have serious physical limitations and are more costly than either concrete or steel.

C. Non-pressure Treatments

1. Profile of the Wood Treatment Industry and Applicators

a. Poles-Groundline

About 350 people are involved in some aspect of poles-groundline treatment of poles with creosote and penta. The products used for this application are prepared as a liquid which are applied with a brush, as a grease-like formulation applied by brush, paddle, scoop, caulking gun or other mechanical applicator, or as impregnants in wrapping or bandages applied around the pole above and below ground level. Inspection and groundline treatment of poles are carried out by small crews (2 to 3 men), with one person usually responsible for the preservative application (USDA-States-EPA, 1980).

TABLE III-28 Estimated Costs of Treated Wood, Concrete, and Steel Poles or Towers in Utility Transmission Systems, 1978 (continued)

Item	Inorganic Arsenical-Treated Poles	Concrete Poles	Steel Poles or Towers
Installed cost per pole (dollars)[a]	1,446	3,838	4,723
Service life (year)	50	35	50
Poles in system (million)	8.33	8.33	8.33
Average number of poles installed per year to maintain the system	166,600	238,000	166,600
Present value of future cost of maintaining system (million dollars)[b]	3,347.29[d]	9,135.96	10,933.10[d]
Annualized cost of maintaining the system (million dollars)[c]	334.73	913.60	1,093.30
Annualized cost per pole (dollars)	40.18	109.68	131.25

a. Weighted average of data supplied by Edison Electric Institute (1979) and Rural Electric Administration (1979).

b. Present value equals the total cost stream for 100 years discounted at 10%.

c. $$\text{Average annual cost} = \frac{\text{Present value} \times (1 + r)^n}{(1 + r)^n - 1} \text{, where } r = 10\% \text{ and } n = 100$$

d. Assumes 238,000 poles per year for 35 years and 0 poles for 15 years.

b. Home and Farm

Penta and creosote products (over-the-counter products) are applied by homeowners, farmers and to some extent by on-the-job carpenters by brushing, rolling, dipping, soaking or spraying the wood. An estimated 3 to 6 million people apply about 1.5 million pounds of penta annually and an estimated 50,000 people apply about 2 million pounds of creosote annually by these methods. Individual applicators normally use creosote or penta only once or twice a year (USDA-States-EPA, 1980).

c. Sapstain Control

In 1977, there were nearly 23,000 United States establishments (e.g., sawmills, planing and logging mills) in the lumber manufacturing industry (U.S. Dept. of Commerce, 1979a,b). The number of logging establishments increased from 13,238 in 1972 to 15,504 in 1977, but the sawmill and planing mill establishments have declined from 8,071 to 7,491 during this same time period. Despite the decline in sawmills and planing mills, the total value of lumber shipments rose to $17 billion in 1977 compared to $9 billion in 1972.

d. Millwork and Plywood

The 1977 Census of Manufactures preliminary report (SIC 2431) for millwork presents the most recent information for the industry (U.S. Dept. of Commerce, 1979c). The 1977 preliminary

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report lists 2,327 millwork establishments of which only 691 establishments employed 20 or more people. Nearly 42% of all the millwork establishments are located in the Pacific, North-Central and Gulf states.

According to the 1977 Census of Manufactures preliminary report, the total value of shipments for millwork establishments was $3.9 billion in 1977 (U.S. Dept. of Commerce, 1979c). California establishments accounted for the highest value of shipments, $573.9 million. The 1977 value of shipments for millwork increased about 64% from that of the 1972 value of shipments for millwork. The products primarily responsible for the increase in the value of millwork shipments were wood window units and wood doors.

Total production of softwood plywood (3/8" basis) increased 3% from 19.38 billion square feet in 1977 to 19.96 billion square feet in 1978 (American Plywood Association, 1979). Of the 182 United States mills producing plywood in 1978, 111 mills were located in the Western region. The percentage share of plywood production of Western and Inland* producers has been gradually declining in the last decade while it has been increasing in the South. The actual volume of plywood increased in all regions except the Inland regions, where there was no change.

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* The definition of producing regions are: 1) Western: California and portions of Washington and Oregon that are west of the the Cascade mountain range, 2) Southern: states south of the Mason-Dixon line and from Virginia to Texas, and 3) Inland: all other areas of the United States not defined in Western and Southern regions.

e. Particleboard

There is currently only one known plant producing penta-treated particleboard. Production of treated particleboard has been relatively consistent in the 70's with the exception of 1979 when only 29.5 thousand square feet of treated particleboard was produced compared to 186.6 thousand square feet in 1978. The average annual value of treated particleboard sold to distributors in recent years is about $35,000 (NFPA, 1979). In 1978, about 3.9 billion square feet (3/4" basis) of particleboard were produced in the United States (NPA, 1979). The National Particleboard Association (1979) reported a value cf shipments of $818 million for the total particleboard production in 1978, almost a 70% increase over 1977.

2. Benefit Analysis by Use Category for Non-pressure Treatments

a. Poles-Groundline

i. Usage and Identification of Use Category

The poles-groundline treatment of in-place utility poles is a small, but increasingly important segment of the wood treatment industry. In poles-groundline treatment, wood preservatives are applied to a previously installed pressure treated pole over a section covering the 6 inches above and 6 inches below the ground level of the pole. This treatment is carried out to prolong pole life by giving extra protection to the most susceptable decay zone of the pole. Decay and subsequent pole failure can be delayed for 20 or more years if the groundline area is given supplementary preservative treatments. The normal poles-groundline treatment cycle involves giving a pole its first treatment 15 or 20 years after installation and following this treatment with a subsequent application after 30 and 40 years of service.

The two major formulations of commercial pole-groundline treatments marketed in the United States both contain creosote and penta; one of these formulations has a high creosote content and the other a high penta content (this product also contains sodium fluoride). Currently, the high creosote formulation is used for about 66% of all poles-goundline treatments and the high penta product is used for about 33% of the poles-groundline treatments.

The number of utility poles receiving poles-groundline treatment in the United States, in 1978, was estimated to range from 900,000 to 1,100,000 poles (for purposes of this analysis, the number of poles treated annually is considered to be 1 million). In this year, the treatment industry used an estimated 172,000 pounds of penta and 655,000 pounds of creosote to treat poles for poles-groundline treatment. The estimated average cost per treatment varies between $10 and $12 per distribution pole and between $14 and $16 per transmission pole (Cravens, 1979; Nagel, 1979). Assuming that about 93% of the treated poles are distribution poles, the total cost in 1978 of poles-groundline application for 1 million poles ranged between $10.3 million to $12.3 million.

ii. Assumptions

The assumptions used in calculating the annualized savings are: 1) cancellation of creosote and penta pressure treatment for poles will not take place, 2) an average of 30 years service life for a treated pole without poles-groundline treatment, 3) an average of 50 years service life for treated poles with poles-groundline treatment, 4) a $350 cost to represent the current average installed replacement cost for a distribution pole and $1,478 for the replacement cost of a transmission pole, 5) a $10 cost for single poles-groundline treatment per pole, 6) an average of 3 poles-groundline treatments for each treated pole, 7) a current interest rate of 10%, and 8) straight line depreciation for the treated poles.

iii. Impacts of Cancellation

The benefits associated with poles-groundline treatment can be estimated by determining the savings in pole replacement costs resulting from an extension of pole life. The pole life can be extended 20 years beyond the assumed 30 year service life of a pole not subject to poles-groundline treatment. The savings resulting from poles-groundline treatment is presented in terms of "annualized" costs (see Section III.4.B, Methods and Assumptions, for definition).

The current costs per pole with and without poles-groundline treatment and the present value of these cost savings associated with poles-groundline treatment are shown in Table III-29 for distribution poles. The total savings from poles-groundline treatment for each treated distribution pole is $203.33 for the 50 year period or $4.07 per year; this is equivalent to a present value of future savings of $16.78. The annualized savings, calculated from the present value of savings (see Section III.B.4, Methods and Assumptions, for equation), is $1.67 for a distribution pole. By a similar calculation, the annualized savings for poles-groundline treatment of transmission poles is $7.80. Assuming that 7% of treated poles are transmission poles and 93% are distribution or telephone poles, the average annualized savings per pole equals $2.21.

TABLE III-29 Calculation of Present Value of Savings per Pole Due to In-Place Poles-Groundline Treatment for Distribution Poles, 1978[a]

	Current Cost per Pole				
Time Period	Without Groundline Treatment	With Groundline Treatment	Difference in Cost	Discount Factors	Present Value of Cost Difference
0	$350.00	$350	0.00	1.0000	$ 0.000
20	0.00	10	-10.00	0.1487	-1.487
30	350.00	10	340.00	0.0573	19.482
40	0.00	10	-10.00	0.0221	-0.221
50	-116.67[b]	0	-116.67[b]	0.0085	-0.992
Total	$583.33	$380	$203.33		$16.782

a. Source: USDA-States-EPA, 1980.

b. The amount of money recovered from the sale of the used treated poles (e.g., salvage value).

If the average annualized savings per pole is multiplied by the number of treated distribution and transmission poles (16.67 million) subject to poles-groundline treatment, the total savings from the poles-groundline treatment program would be $35,340,400 per year. If the current level of poles-groundline treatment doubles within the next five years as some experts have predicted, the potential savings will exceed $70 million per year (Cravens, 1979).

If poles-groundline treatment were cancelled, about 222,300 additional replacement poles would be required each year starting 10 years after poles-groundline cancellation and the average installed cost for the these additional treated wood poles would be about $77.8 million at present price of $350 per distribution pole. If the current level of poles-groundline treatment doubles in the next 5 years, the future annual pole requirements will rise about 450,000 per year and the average installed cost for the additional treated poles would be about $167.5 million at present price of $350 per distribution pole.

b. Home and Farm

i. Usage and Identification of Use Category

Penta and creosote solutions are applied by homeowners, farmers and to some extent, by on-the-job carpenters, by brushing, rolling, dipping, soaking or spraying the wood. Typical treated wood items include decks, siding, millwork, lumber, fences, shingles, outdoor furniture and other miscellaneous wood products.

Homeowners and farmers rely heavily on non-pressure applications of penta and creosote formulations to extend the useful service life of wood in aboveground applications and to obtain limited protection for wood in contact with the ground. Because of low retentions and poor penetration of these non-pressure formulations into the wood, groundline (or below ground) treatment is less effective for control than aboveground applications (USDA-States-EPA, 1980).

About 1.6 million pounds of penta and 2.0 million pounds of creosote are used around homes and farms to protect various wood structures and products exposed to natural elements. The 1.6 million pounds of penta used for home and farm use represent 48% of the total non-pressure applications, but only 4.3% of penta's total usage as a wood preservative. The creosote sold for home and farm use represents only about 0.1% of creosote sold for wood preservation (USDA-States-EPA, 1980).

Representative penta products available for retail sale include: 1) a 5% penta ready-to-use solution in oil, 2) a concentrate containing 40% penta which is diluted with fuel or diesel oil (1/10 dilution), 3) a penta water repellent concentrate which is diluted with oil or mineral spirits (1/5 dilution), and 4) a ready to use 5% penta water repellent preservative. These products, particularly the ready-to-use solutions, are commonly sold in 1 quart, 1 gallon or 5 gallon containers; large volume containers are also available for the concentrate. Large volumes (e.g., 55 gallon drums) of the concentrated products would most likely be purchased by farmers, who would have a need for large volumes of wood preservatives and would have the diesel and fuel oil for dilution readily available.

The ready-to-use water repellent penta formulation is the most widely used treatment for standing structures (e.g., fences, sheds, etc.) and is also widely used for building materials such as window frames. Several water repellent stains containing penta are available, although the most widely used products are the clear solutions which can be covered with stain, paint, varnish or left unfinished. The water repellent material present in penta formulations prevents the warping, checking, swelling and shrinking of the wood which is caused by the changes in moisture content of the wood.

Creosote and coal tar neutral oil products are available in various concentrations of active ingredients ranging from 21.5% to 99.0%, with the 90-99% range products the most commonly used (Cummings, 1980). These products are generally used by farmers for soaking fence posts and lumber and for in-place remedial treatments (NFPA, 1980).

The non-pressure inorganic arsenicals treatments are not available to home and farm applicators and are only available to commercial applicators (e.g., pressure treatment plant, construction companies). About 2,000 to 3,000 gallons of a 3% inorganic arsenical solution is annually sold to commercial applicators for field treatment (outdoor applications only) on cut-ends of inorganic arsenical-treated wood during fabrication (USDA-States-EPA, 1980).

ii. Availability and Efficacy of Alternatives

Availability of Alternatives

There are several alternative wood preservatives registered for use at the home and farm level, the most common being copper naphthenate, copper-8-quinolinolate (Cu-8), zinc naphthenate and tributyltin oxide (TBTO). Products containing these chemicals are available for sale at most lumber and hardware stores.

Copper-8-quinolinolate (Cu-8) is registered for application at concentrations from 0.25% to 0.30% for use on wood items (the product is usually sold as a concentrate to be diluted with oil). The retail availability of Cu-8 products is limited because the high cost in manufacturing and the low demand for the Cu-8 products by the consumers has made the manufacture of this preservative uneconomical. One registrant (manufacturer) has developed a water-based Cu-8 formulation (rather than oil) which is available for industrial use, but is not currently available for home and farm use (Nagel, 1980).

Several copper naphthenate, zinc naphthenate and TBTO preservative products are registered for sale to homeowners and farmers. The Agency has no information on the volume of these chemicals actually sold for home and farm application.

Alternatives to non-pressure treatment include leaving the wood untreated, using non-wood materials (e.g., aluminum, concrete) or purchasing lumber which has been pressure treated. The only untreated wood which would be decay resistant are the naturally resistent wood species and are only available in small supply.

Comparative Efficacy

Non-pressure applications of penta have been effectively used for nearly 40 years and are primarily effective for aboveground use, but do provide some control when wood is used in ground contact. Penta-treated wood is colorless, paintable and stainable.

Generally, non-pressure applications (e.g., brush, dip and spray) of creosote to dry, sound untreated wood are effective for above ground, but are generally ineffective for ground contact. Properly applied hot and cold soak treatments of creosote will provide some protection for wood which is used in ground contact (USDA-States-EPA, 1980). However, creosote formulations discolor wood and leave the wood unpaintable. Penta can be substituted for creosote, but creosote is only an effective alternative for penta where a paintable or light colored, odorless, clean wood is not required.

Copper naphthenate is effective under certain conditions, but its overall performance is questionable (NFPA, 1979). The copper naphthenate solutions contain water repellents and most of these formulations, including those containing color stains, are recommended for aboveground use only. There are, however, a few "extra strength" products which give use directions for treating wood which will be used in contact with the soil. In addition to the questionable effectiveness, copper naphthenate imparts a green color to the wood, makes a poor base for paint and leaves the wood difficult to finish naturally. Another alternative, zinc naphthenate, imparts a colorless finish to wood, but is considered less effective than copper naphthenate.

The TBTO formulations are colorless in solution and leave the wood clear and paintable. This chemical has some known merit for protecting wood aboveground, but is ineffective for ground contact use (NFPA, 1979).

Cu-8 formulations (0.25% to 0.30%) have been used in the past to protect wood and are registered for use on wood which will be in contact with food. Various formulations, in water repellents, prevent water absorbtion, swelling and checking of the wood, but apparently have demonstrated less effectiveness in controlling rot and decay than either creosote, inorganic arsenicals and penta. In fact, the use of Cu-8 by homeowners and farmers has been declining in recent years. Some manufacturers no longer supply their products to retail stores presumably due to higher product costs than other preservatives and hence a small demand for Cu-8 products.

All of the above wood preservatives lack the wide range of control characteristic of penta, but are partial substitutes for certain penta uses. For instance, creosote and copper naphthenate can be used where a paintable, light color, odorless or clean wood is not required. Copper naphthenate can be used when the desired color of wood is not important. For strictly above ground use, where paint is to be applied, TBTO will provide effective control at the registered concentration.

The USDA-States-EPA Assessment Team (1980) recommends Cu-8 and TBTO as acceptable alternatives for penta only at a 2% concentration (unregistered formulations). At this concentration, these Cu-8 and TBTO products would protect the wood from decay and insects better than their registered concentrates.

Aluminum, concrete, plastic or other construction materials can be substituted only for limited uses of the non-pressure treated wood; these materials would be expected to have a reasonably longer service life than the non-pressure treated wood (USDA-States-EPA, 1980). Untreated wood can be used, but it has a substantially shorter service life for exterior exposure (except cedar and redwood) than treated wood.

The protection provided by pressure treatment with the inorganic arsenicals is superior than that provided by non-pressure penta and creosote treatments for ground contact applications (USDA-States-EPA, 1980). CCA- or ACA-treated lumber, timber and plywood gives predictable performance in a wide range of exposure situations and are highly effective for ground contact uses. In recent years, lumber, plywood and fence posts pressure treated with CCA or ACA have become more readily available to carpenters, homeowners and farmers. However, the inorganic arsenical-treated lumber (pressure) can only be considered a partial substitute for home and farm uses of non-pressure applications of penta and creosote since treated lumber is not an alternative for the supplemental treatment of standing structures.

iii. Impacts of Cancellation

The cancellation of non-pressure applications of both creosote and penta for home and farm uses would lead to the substitution of alternate wood preservatives, non-wood materials (e.g., aluminum) or pressure treated wood (e.g., CCA). Non-wood materials (e.g., aluminum and steel) can replace wood in some circumstances and are comparable in price for some uses. The economic analysis of the cost differental for non-wood materials does not, however, take into account the aesthetic value of wood.

There are several preservative products (e.g., copper naphthenate, zinc naphthenate, Cu-8 or TBTO) currently available to homeowners and farmers as substitutes for penta or creosote products. None of these chemicals give the overall performance imparted by penta or creosote, but all are efficacious under some conditions. However, the prices of these alternative products are notably higher than the price of the penta or creosote products.

The average prices for the registered formulations of various wood preservative products are presented in Table III-30. Wood preservative prices vary depending on the type of product or concentrate. The most commonly used formulation is a ready-to-use 5% penta solution in mineral spirits which costs about $9.50 per gallon. The price of a typical 98% creosote coal tar solution is approximately $7.50 per gallon. Zinc naphthenate (13.5% solution) costs $12.40 per gallon; copper naphthenate (20% solution) $13.45 per gallon; and TBTO (0.3% solution) $14.50 per gallon (no price was obtained for Cu-8 products). If the TBTO and Cu-8 products were formulated and registered at the concentration of 2.0% recommended by USDA-States-EPA Assessment Team, the costs to the consumer would be substantially higher than the cost for the currently registed TBTO and Cu-8 products.

TABLE III-30 Home and Farm: Average Retail Price[a] of Various Wood Preservative Products, 1978-1979

Type of Solution	Active Ingredient	Retail Price (dollars per gallon)
Ready-to-use in fuel oil	5% penta	7.40
10-1 concentrate to be diluted with fuel or diesel oil	40.0% penta	13.60
Ready-to-use in more volatile solvents (mineral spirits) with water repellents (clear, pigmented and paintable)	5% penta	9.50
Ready-to-use with water repellents (green)	20% copper naphthenate (2.0% metallic copper)	13.45
Ready-to-use with water repellents (clear)	13.5% zinc naphthenate (2.0% metallic zinc)	12.40
Ready-to-use in mineral spirits with water repellents (clear, pigmented and paintable)	0.3% TBTO (bistributyltin oxide)	14.50
Ready-to-use	98.5% refined coal tar creosote	7.50

a. Based on spot check of several lumber and hardware stores in the Washington, D.C. area (including parts of Maryland and Northern Virginia) as well as personal communications with Roberts Consodidated, Darworth Inc., Chapman Chemical and Koppers Chemical Company.

Instead of dip or brush treating lumber with over-the-counter wood preservatives, a farmer or homeowner can use lumber that has been pressure treated. The price of pressure treated lumber is slightly higher than lumber treated by brush or dip, but the pressure treated lumber provides better protection. The use of pressure treated wood does not substitutue for the supplemental treatment of standing structures or the treatment of cut ends of pressure treated wood.

Table III-31 presents the average prices for lumber of various dimensions for both untreated wood and wood pressure-treated with CCA. The cost of a 5% ready-to-use penta in mineral spirits solution for treatment of lumber boards of various dimensions is presented in Table III-32. The cost for penta depends on the dimension of the wood and the coverage afforded by the penta solution (coverage varies with the surface condition of the wood). Table III-33 compares the cost of untreated lumber and the cost of the brush-on penta solution required to treat this lumber with lumber pressure treated with CCA, assuming that one gallon of penta solution ($9.50/gal.) covers 200 square feet of lumber.

The available data are insufficient to perform a detailed analysis of cost impacts due to cancellation. The economic impacts on price and production of alternatives from the increased demand caused by cancellation of penta and/or creosote are difficult to measure due to the large number of uses involved in this use category.

TABLE III-31 Retail Prices[a] of Pressure Treated and Untreated Dimensional Lumber, 1980

Size	Unit of Measure	Price of Untreated Lumber[b] (dollars)		
		low	high	average[c]
2" x 4" x 8'	per board	$ 1.39	1.85	1.69
2" x 6" x 12'	per board	4.39	6.85	5.60
2" x 8" x 12'	per board	5.30	9.00	7.30
	1,000 board feet[d]	330.00	562.50	453.00
2" x 10" x 12'	per board	6.95	13.30	10.35
	1,000 board feet[d]	347.50	660.00	485.00

a. Source: Based on a spot check of several lumber and hardware stores in the Washington, D.C. area (including parts of Maryland and Northern Virginia), January, 1980.

b. Untreated dimensional lumber is usually #2 grade southern yellow pine. Other species also used are #1 southern yellow pine, spruce, and Douglas-fir. The #2 yellow pine is the least costly of the four. Untreated lumber is almost always kiln dried.

c. The average price was calculated using all the prices gathered and is not the medium of the low and high prices presented in this table.

d. Some retails stores offered discounts when lumber is brought in large quantities (e.g., 1,000 board feet).

TABLE III-31 Retail Prices[a] of Pressure Treated and Untreated Dimensional Lumber, 1980 (continued)

Size	Unit of Measure	Price of Treated Lumber[e] (dollars)		
		low	high	average[c]
2" x 4" x 8'	per board	$ 2.25	3.35	2.60
2" x 6" x 12'	per board	6.00	7.95	6.75
2" x 8" x 12'	per board	8.00	10.60	9.00
	1,000 board feet[d]	448.00	662.50	555.00
2" x 10" x 12'	per board	11.10	13.25	12.15
	1,000 board feet[d]	555.00	712.50	592.00

a. Source: Based on a spot check of several lumber and hardware stores in the Washington, D.C. area (including parts of Maryland and Northern Virginia), January, 1980.

c. The average price was calculated using all the prices gathered and is not the medium of the low and high prices presented in this table.

d. Some retails stores offered discounts when lumber is brought in large quantities (e.g., 1,000 board feet).

e. This is lumber pressure treated with CCA. Treated dimensional lumber is normally either #1 or #2 grade southern yellow pine. Lumber pressure treated with CCA at 0.40 pounds of retention per cubic foot has a longer expected service life than lumber treated at 0.25 pounds of retention. Some applicators include a more extensive kiln drying process to lower moisture content of the wood. All these factors are partly responsible for the varying prices.

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TABLE III-32 Home and Farm: Cost per Board of Penta Solution Used to Treat New Lumber by Brush-on or Dip Treatments, 1978[a]

Coverage per Gallon of Solution	Cost[b] of Penta per Board for Lumber of Various Dimensions			
	2" x 4" x 8'	2" x 6" x 12'	2" x 8" x 12'	2" x 10" x 12'
Square Feet	- - - - - - - - - - - -	Dollars	- - - - - - - - - - - - -	
100	0.76	1.52	1.90	2.28
200	0.38	0.76	0.95	1.14
300	0.25	0.51	0.63	0.76
400	0.19	0.38	0.48	0.57
500	0.15	0.30	0.38	0.46

a. Source: USDA-States-EPA, 1980.

b. The costs are based on the following equation

$$\text{Cost of penta per board} = \frac{\text{Price of penta solution x square feet per board}}{\text{Square feet of lumber covered per gallon of solution}}$$

Price of penta is $9.50 per gallon.

Dimension of the Lumber	Cubic Feet	Square Feet
2" x 4" x 8'	0.357	8
2" x 6" x 12'	0.80	16
2" x 8" x 12'	1.07	20
2" x 10" x 12'	1.34	24

TABLE III-33 Comparative Prices[a] of Non-pressure Treated and Pressure Treated Lumber, 1978

Dimension of the Lumber	Average Price of Untreated Lumber[b]	Cost of Penta Solution[c]
	(dollars per board)	(dollars per board)
2" x 4" x 8'	$ 1.69[c]	$ 0.38
2" x 6" x 8'	$ 5.60	$ 0.76
2" x 8" x 12'	$ 7.30	$ 0.95
2" x 10" x 12'	$10.35	$ 1.14

a. Source: USDA-States-EPA, 1980.

b. Cost based from Table III-31.

c. Assumes a ready-to-use 5% penta in mineral spirits solution containing water repellents. The price of the solution is $9.50 per gallon. One gallon covers about 200 square feet.

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TABLE III-33 Comparative Prices of Non-pressure Treated and Pressure Treated Lumber, 1978 (continued)

Dimension of the Lumber	Direct Cost of Non-pressure Treated Lumber[d]	Average Price of Treated Lumber[e]
	(dollars per board)	(dollars per board)
2" x 4" x 8'	$ 2.07	$ 2.60
2" x 6" x 8'	$ 6.36	$ 6.75
2" x 8" x 12'	$ 8.25	$ 9.00
2" x 10" x 12'	$11.49	$12.15

d. This is only the cost of the materials, lumber and preservative, but this cost does not include such costs as labor involved in applying the preservative.

e. Lumber pressure treated with CCA.

c. Sapstain Control

i. Usage and Identification of Use Category

Although the most serious structural damage to wood is caused by insects and decay, the discoloration caused by stain fungi is also a major problem. The most prevalent of the fungus stains is sapstain, often referred to as "blue stain". Sapstain fungi penetrate the sapwood of hardwoods and softwoods and cannot be easily removed by surface cleaning.

Sapstain infestation has little effect on the strength of the wood, but can increase the capacity of the wood to absorb moisture which makes the wood more vulnerable to decay. Moreover, discoloration caused by the sapstain is objectionable to wood users and reduces the market value of the wood (Nicholas, 1973; Georgia CES, 1977).

Currently, sodium pentachlorophenate (Na-penta) is the primary antimicrobial used to control sapstaining and surface staining fungi (molds). About 1.15 million pounds (derived from 1.02 million pounds of penta) of Na-penta are used annually for this purpose (NFPA, 1979). This amount of Na-penta represents nearly 29% of the non-pressure uses of penta, but less than 2.7% of the total estimated 37 million pounds of penta used as a wood preservative (USDA-States-EPA, 1980). The penta solutions often include the salts of other chlorinated phenols. About 1.4

million pounds of chlorinated phenates are used annually for sapstain control (NFPA, 1979).

Na-penta is most frequently applied to green lumber and shaved round stock (e.g., poles and posts). Freshly peeled poles and posts are treated with Na-penta to prevent sapstain growth during air seasoning prior to pressure treatment. Green lumber is treated with Na-penta to provide protection from sapstain during storage and transportation.

Data on the amount of lumber and shaved round stock treated with Na-penta to prevent sapstain growth are not available. Assuming that only lumber (as opposed to poles and posts) was treated with Na-penta, the volume of lumber treated for sapstain control in 1978 is estimated to be 3.58 billion board feet. Of this total, 2.08 billion board feet were domestic lumber and 1.5 billion board feet were lumber for export (EPA, 1980). Virtually all lumber for export (94%) is treated with Na-penta for sapstain control (NFPA, 1979). The total lumber production in the United States, in 1978, was estimated to be about 568.5 billion board feet (NFPA, 1979).

ii. Methods of Application

Na-penta for sapstain control is formulated primarily as a liquid concentrate (generally 28% active ingredient), but is also available as a dry powder (Nagel, 1980). Sapstain treatments are typically made with a water-diluted solution.

The concentration of the diluted solution depends on the degree of control required. In terms of total lumber treated, almost all lumber for export is treated with a 1:50 solution; approximately one half of the Na-penta treated domestic lumber is treated with a 1:60 solution and the remainder is treated with a 1:100 solution of Na-penta (USDA-States-EPA, 1980). The Agency does not have any information on the concentration level of the solution applied to poles and posts.

Na-penta solutions used for sapstain control are usually applied to green lumber by the "across-chain dip method." In this procedure, the untreated lumber, which is conveyed through the sawmill on a chain known as the "green chain", passes through a tank containing Na-penta solution where the lumber is dipped for a number of seconds. An alternative procedure, which is not as prevalent as the across-chain dip method, but is similar to the dip method, uses a spray tunnel instead of a dip tank. Another treatment method involves stacking the lumber in bundles and then dipping the bundles in Na-penta solution. This method is known as bulk dipping and is infrequently used to apply Na-penta for sapstain control (NFPA, 1979).

Poles and posts are treated with Na-penta most often by spraying the poles or posts as soon they emerge from the bark peeler (NFPA, 1979). The purpose of this treatment is to protect the poles and posts during air seasoning before they can be kiln dried and pressure treated.

iii. Use and Efficacy of Alternatives

The alkali salts of tetrachlorophenol (tetra), like those of penta, have been used effectively for sapstain control for over 40 years (NFPA, 1979). In recent years, the supply of Na-tetra in this country has declined and Na-tetra has been replaced by Na-penta as the primary antimicrobial for sapstain control. Na-tetra and potassium tetrachlorophenate (K-tetra) have been typically used in combination with lower concentrations of sodium trichlorophenate (Na-TCP) and potassium trichlorophenate (K-TCP). Even though salts of TCP concentrates are considered twice as effective as Na-tetra and Na-penta concentrates, the use of these TCP salts is limited because of cost (Nagel, 1980). No information is available on the volume of tetra and TCP used for sapstain control.

Cu-8-quinolinolate is also registered with EPA for sapstain control and is currently used to achieve control of sapstain fungi (NFPA, 1980). Cu-8 has not been as extensively used as the chlorinated phenols and information is not available on the volume of Cu-8 used for sapstain control. The quantity of Cu-8 used is believed to be considerably smaller than the amount of the chlorinated phenols applied. There is also limited information on the effectiveness of Cu-8 under actual end-use conditions of the treated wood.

Kiln drying can also be used effectively to prevent sapstain for most softwoods by reducing the moisture content of the wood below 20% (the minimum moisture level suitable for sapstain growth) and is the preferred method, where feasible (Georgia CES, 1977). However, kiln drying use cannot be utilized in those situations where freshly-cut lumber cannot be placed in the kiln within 48 hours, as sapstain growth will begin at or about this time period (NFPA, 1979). Kiln drying is also not appropriate for a number of hardwood species which are subject to warping and honeycombing during kiln drying.

iv. Impacts of Cancellation

In the event of cancellation of Na-penta, Na-penta applicators most likely will switch to Na-tetra which is equally efficacious and of equal cost. Although effective, TCP is more costly for a registrant to formulate and, therefore, its use by applicators may only increase slightly. Another possible alternative for sapstain control is Cu-8, although Cu-8's performance under extreme conditions is not believed to be adequate (NFPA, 1979). There will be minor changes in treatment cost if an applicator switches from Na-penta to one of the above chemical alternatives for sapstain control.

The costs of Na-penta and alternative products are presented in Table III-34. The price of a gallon of Na-penta or Na-tetra concentrate are essentially equivalent and are considerably lower than the prices of the alternatives concentrates (Cu-8, Cu-8 and Tetra, and K-tetra and K-TCP). However, when diluted in accordance with label recommendations, the diluted alternative products are competitively priced with the diluted Na-penta products.

Table III-35 presents the estimated volume of lumber treated with Na-penta for sapstain control and the comparative costs of treating this volume with Na-penta and various alternatives. The cost of treating 3.58 billion board feet of green lumber with Na-penta or Na-tetra solutions is $2.77 million.

Cancelling Na-penta as a sapstain control could result in serious economic losses to the lumber industry without the availability of alternative preservatives. The extent of these losses would depend on the level of grade reduction which results from the lack of control of sapstain fungi (NFPA, 1979). Discloration caused by fungus would not likely be a major concern of pole and post producers, but the decrease in permeability of the wood caused by sapstain may lead to decay during air seasoning and would create substantial economic losses (NFPA, 1979).

TABLE III-34 Comparative Costs of Sodium Pentachlorophenate, Copper-8-Quinolinolate, Copper-8-Quinolinolate and Tetrachlorophenol, and Potassium Trichlorophenate for Sapstain Control, 1978

Item	Unit	Na-Penta[*]		
		Export Treatment	Domestic Treatment	
		All Treatments	50 percent	50 percent
Cost per gallon concentrate[a]	\$/gal[b]	5.75	5.75	5.75
Percent of chemical in concentrate[a]	% by weight	28.00	28.00	28.00
Gallons of concentrate per gallon of solution[a]	concentrate/ dilution ratio	0.02	0.017	0.01
Cost of solution[c]	\$/gal	0.12	0.10	0.06
Application rate of solution[a]	gal/MBF	8.00[e]	8.00	8.00
Chemical cost per MBF[e]	\$/MBF	0.96	0.80	0.48

[*] Costs for Na-tetra solutions would be equivalent to the Na-Penta solution.

a. Nagel, F., Chapman Chemical Co., 1980.

b. Market price.

c. Cost of concentrate times concentrate/dilution ratio.

d. Application rate ranges from 8 to 10 gallons of water-diluted solution per million board feet (MBF).

e. Application rate times cost of solution.

TABLE III-34 Comparative Costs of Sodium Pentachlorophenate, Copper-8-Quinolinolate, Copper-8-Quinolinolate and Tetrachorophenol, and Potassium Trichlorophenate for Sapstain Control, 1978 (cont'd)

Item	Unit	Cu-8		
		Export Treatment	Domestic Treatment	
		All Treatments	50 percent	50 percent
Cost per gallon concentrate[a]	$/gal[b]	12.50	12.50	12.50
Percent of chemical in concentrate[a]	% by weight	5.40	5.40	5.40
Gallons of concentrate per gallon of solution[a]	concentrate/ dilution ratio	0.13	0.10	0.005
Cost of solution[c]	$/gal	0.17	0.13	0.06
Application rate of solution[a]	gal/MBF	8.00[d]	8.00	8.00
Chemical cost per MBF[e]	$/MBF	1.36	1.04	0.48

a. Nagel, F., Chapman Chemical Co., 1980.

b. Market price.

c. Cost of concentrate times concentrate/dilution ratio.

d. Application rate ranges from 8 to 10 gallons of water-diluted solution per million board feet (MBF).

e. Application rate times cost of solution.

TABLE III-34 Comparative Costs of Sodium Pentachlorophenate, Copper-8-Quinolinolate, Copper-8-Quinolinolate and Tetrachorophenol, and Potassium Trichlorophenate for Sapstain Control, 1978 (cont'd)

Item	Unit	Cu-8 and Tetra Export Treatment	Cu-8 and Tetra Domestic Treatment	
		All Treatments	50 percent	50 percent
Cost per gallon concentrate[a]	\$/gal[b]	14.50	14.50	14.50
Percent of chemical in concentrate[a]	% by weight	5.00 (Cu-8) 16.30 (Tetra)	5.00 16.30	5.00 16.30
Gallons of concentrate per gallon of solution[a]	concentrate/dilution ratio	0.008	0.007	0.004
Cost of solution[c]	\$/gal	0.12	0.10	0.06
Application rate of solution[a]	gal/MBF	8.00[d]	8.00	8.00
Chemical cost per MBF[e]	\$/MBF	0.96	0.80	0.54

a. Nagel, F., Chapman Chemical Co., 1980.

b. Market price.

c. Cost of concentrate times concentrate/dilution ratio.

d. Application rate ranges from 8 to 10 gallons of water-diluted solution per million board feet (MBF).

e. Application rate times cost of solution.

TABLE III-34 Comparative Costs of Sodium Pentachlorophenate, Copper-8-Quinolinolate, Copper-8-Quinolinolate and Tetrachorophenol, and Potassium Trichlorophenate for Sapstain Control, 1978 (cont'd)

Item	Unit	K-Tetra and K-TCP		
		Export Treatment	Domestic Treatment	
		All Treatments	50 percent	50 percent
Cost per gallon concentrate[a]	$/gal[b]	13.50	13.50	13.50
Percent of chemical in concentrate[a]	% by weight	31.40 (K-tetra) 7.30 (K-TCP)	31.40 7.30	31.40 7.30
Gallons of concentrate per gallon of solution[a]	concentrate/ dilution ratio	0.01	0.007	0.005
Cost of solution[c]	$/gal	0.14	0.09	0.07
Application rate of solution[a]	gal/MBF	8.00[d]	8.00	8.00
Chemical cost per MBF[e]	$/MBF	1.12	0.72	0.56

a. Nagel, F., Chapman Chemical Co., 1980.

b. Market price.

c. Cost of concentrate times concentrate/dilution ratio.

d. Application rate ranges from 8 to 10 gallons of water-diluted solution per million (MBF).

e. Application rate times cost of solution.

TABLE III-35 Volume of United States Lumber Products and Comparative Costs of Treatment with Na-Penta and Alternative Formulations, 1978

Product	Volume (billion board feet)	Percent	Solution Costs[a]			
			Na-Penta[b]	Cu-8	Cu-8/ Tetra	K-Tetra/ K-TCP
			------ million dollars -------			
Domestic Lumber (Total treated)	2.08	100	1.33	1.33	1.39	1.33
50% Treated[c]	1.04	50	0.83	0.83	0.83	0.75
50% Treated[c]	1.04	50	0.50	0.50	0.50	0.38
Lumber for Export	1.50	100	1.44	1.55	1.44	1.55
Hardwood	0.32	21	0.31	0.33	0.31	0.33
Softwood	1.18	79	1.13	1.22	1.13	1.22
Total Wood Treated	3.58	---	2.77	2.88	2.83	2.88

a. Volume treated times cost of solution (Table III-6).

b. Costs of Na-tetra solutions would be equivalent to Na-penta solutions.

c. Assuming the following dilute ratios based on label recommendations:

	50% lumber treated dilute ratio*	50% lumber treated dilute ratio*
Na-penta	1:60	1:100
Cu-8	1:100	1:200
Cu-8/Tetra	1:150	1:250
K-tetra/K-TCP	1:150	1:200

*Diluted with water

d. Millwork and Plywood

i. Usage and Identification of Use Category

Millwork includes wood windows, sash screens, blinds, shutters, window frames, doors, door frames and mouldings, as well as machined parts of these products (NFPA, 1979). All of these items are manufactured primarily from ponderosa pine and other softwoods. An estimated 80% of the lumber used for manufacturing millwork in 1978 was softwood (NFPA, 1979). Softwoods have a low natural resistance to decay and must be treated if a prolonged service is expected.

Penta water-repellent solutions are applied to exterior millwork products to prevent decay and/or insect infestation. The penta and water repellents protect the millwork after installation, primarily for aboveground exposure. Only about 1.6% (600,000 pounds) of total penta used for wood preservation was used by the millwork industry in 1978 (USDA-States-EPA, 1980). The 600,000 pounds of penta consumed by the industry were used to treat approximately one-third of the 1 billion board feet of all millwork manufactured in 1978 (NFPA, 1979).

Penta water-repellent solutions are sometimes applied to softwood plywood in addition to millwork. Less than 0.1% (15 million square feet) of the more than 19 billion square feet of softwood plywood (3/8" basis) produced annually is treated with penta and consumes less than 50,000 pounds of penta (NFPA, 1979). The most prevalent plywood use of the penta solution is as a water repellent and mildewcide for textured plywood siding, specifically redwood siding (NFPA, 1979).

ii. Methods of Application

Millwork and plywood are usually treated with a 5% penta solution in mineral spirits (containing water repellents) which is applied by spraying, brushing, dipping (cold or hot preservative treatment) or by the vacuum process (NFPA, 1979). Penta is applied to millwork primarily by the dipping and vacuum process. Remachined or cut pieces of wood are often brush treated to protect exposed edges from decay. Plywood is typically treated by dipping or spraying.

iii. Availability and Efficacy of Alternatives

Availability of Alternatives

A number of wood preservative products containing 0.3% tributyltin oxide (TBTO) are currently available for retail sale for home and farm use for millwork. The 0.3% TBTO concentration does not provide the protection required by the millwork industry and is not approved by the National Wood Manufacturers Association (NWMA) for this use (Arsenault, 1980). Some millwork manufacturers have been known to make their own TBTO solutions from concentrates (amount of TBTO used is not known) and others have used solutions containing both penta and TBTO

(Arsenault, 1980). Within the last year, a 0.75% TBTO solution has been registered as a preservative for millwork (Arsenault, 1980).

Copper-8-quinolinolate concentrates for industrial use that are registered for millwork are diluted with mineral spirits to obtain a 0.25% Cu-8 ready-to-use solution (Nagel, 1980). Although these Cu-8 concentrates are approved by NWMA for millwork preservation, the volume used has been small (Nagel, 1980). A water-based Cu-8 concentrate for general wood preservation has been available for over five years and is diluted with water, rather than petroleum oil or mineral spirits, to a 0.5% Cu-8 ready-to-use solution (Nagel, 1980). This water-based concentrate is registered for millwork preservation, but it is not approved by the NWMA for this use (Nagel, 1980). No information is available regarding the amount of water-based Cu-8 currently used by the millwork industry.

Other structural materials, particularly aluminum, are commonly used to manufacture some millwork items such as windows and doors (NFPA, 1979). Information on the total volume of non-wood millwork products produced is unavailable.

Comparative Efficacy

Penta has been the standard wood preservative used by the millwork industry for more than 40 years and has proven its effectiveness against decay as well as several insect species

(NFPA, 1980). Penta is colorless, compatible with paints, stains, sealers and primers and does not interfere with the adhesion of glazing compounds, caulkings or other sealants (NFPA, 1979). These characteristics are necessary for preservatives to be used on millwork.

The 0.3% TBTO and the 0.25% and 0.50% Cu-8 products provide limited protection when applied by brush, dip or spray, but may not provide the more extensive protection necessary for millwork. However, the 0.75% TBTO solution is an effective preservative for exterior millwork, specifically for aboveground use of millwork which is subsquently painted, varnished or coated (NFPA, 1980). If millwork is subjected to severe exposure (e.g., soil contact), the prolonged service life provided by the 0.75% TBTO solution will not equal that of penta (NFPA, 1980).

The Cu-8 concentrates when diluted with mineral spirits to make a 0.25% to 0.3% Cu-8 ready-to-use solution are approved by the NWMA, but not recommended by the National Forest Products Association for millwork protection (NFPA, 1980; Nagel, 1980). The NWMA requires that preservatives for millwork should have petroleum carriers and has not yet approved the water-based Cu-8 product for millwork applications (Nagel, 1980).

iv. Impacts of Cancellation

Penta solutions are sold to millwork manufacturers primarily in tank trucks or cars (Arsenault, 1980). The price of the ready-to-use solution of penta based on a bulk rate is about $1.70 per gallon plus the freight cost. The largest portion of this cost is the mineral spirits (0.8 pounds per gallon of solution). Mineral spirits currently cost about $1.20 per gallon and the price has been rising with the cost of oil (Arsenault, 1980). The bulk price of the 0.75% ready-to-use solution of TBTO is approximately the same as the penta.

A 3.75% Cu-8 concentrate for dilution with mineral spirits cost about $7.00 per gallon in bulk (Nagel, 1980). The cost of the Cu-8 and the mineral spirits for a gallon of a 0.25% Cu-8 ready-to-use solution, which is assumed to provide effective protection for millwork, is about $1.60. This price would be slightly higher when adjusted for delivery cost (Nagel, 1980). If a 10% Cu-8 water based concentrate is used, the estimated cost is $12.50 per gallon in bulk (Nagel, 1980). Assuming a zero cost for water, the price for a 0.5% to 2.0% ready-to-use Cu-8 solutions would range from $0.65 to $2.50 per gallon.

If penta were cancelled for millwork treatment, applicators would likely switch to a 0.75% TBTO solution which is similar in cost to penta and has shown effectiveness for above ground exposure when painted (NFPA, 1979). If the water-based Cu-8 solution proves its effectiveness, many penta applicators would switch to Cu-8 products.

Other alternatives for millwork include the use of naturally resistant wood, untreated wood and non-wood materials. Due to the short supply of naturally resistant wood and the frequent replacements required for untreated wood, the most likely non-chemical alternative would be the use of non-wood materials.

There is very little economic data available for treated softwood plywood and the Agency lacks economic information on the cost of treated and untreated plywood for the plywood markets. The cost impact of the cancellation of penta for treatment of softwood plywood does not appear to be significant due to the small volume of softwood treatment. TBTO could replace penta for those uses where the treated plywood could be painted. The effectiveness of Cu-8 for plywood has not been proven by actual field use experience (Arsenault, 1980).

e. Particleboard

i. Usage and Identification of Use Category

In some areas of the United States it may be necessary to treat particleboard to prevent attack by dry-wood termites and other wood destroying insects. Penta is presently the only effective preservative used for this specific purpose. There is currently only one known plant producing penta-treated particleboard. Annually less than 10,000 pounds (about 1,000 gallons) of penta are used to treat an average of about 170,000 square feet (3/4" base) of particleboard (NFPA, 1979). This treated particleboard makes up less than 1% of the average annual particleboard production at the plant and represents a very small part (about 0.005%) of the 3.9 billion square feet of particleboard produced in the United States in 1978 (National Particleboard Association, 1979).

The penta-treated particleboard can be made in thickness ranging from 3/8" to 1 3/4" and any size up to 5' x 16'. The finished penta-treated particleboard is sold to distributors and eventually used in cabinets and outside furniture in certains areas of the United States where there is a high occurrence of termite attack, specifically Hawaii.

ii. Methods of Application

The individual wood particles in particleboard are bonded together by the polymerization of urea-formaldehyde resin. During the manufacturing process, the penta solution (0.65% penta solids based on oven dry weight of the wood), resin and wax emulsion are applied to the wood particles at the same time. After treatment, the wood particles are conveyed to a forming station where the material is formed into a mat and then to the press where the mats are consolidated into boards (NFPA, 1979).

iii. Availability of Alternatives

There are no known chemical alternatives that are registered for this specific use of penta. One unique characteristic of penta is its ability to be mixed directly with the resins and wax in the production of particleboard.

No substitute chemical has been used in the manufacture of treated particleboard nor has any substitute been found that is compatible with the urea-formaldehyde resin or that gives the level of protection provided by penta (NFPA, 1979; Cheo, 1979).

There are, however, several chemicals registered for controlling drywood, dampwood or subterranean termites, namely: copper naphthenate, anthracene oil, chlordane, copper-8-quinolinolate, copper acetoarsenic, ethylene dibromide, zinc naphthenate and ortho-dichlorobenzene. Since the termite infestation occurs during end-use, it may be possible to treat the finished particleboard with these other pesticides. However, the effectiveness of these pesticides for preventing termite infestation when particleboard is treated in service is not known. There are also no data available comparing the termite resistance of penta-treated and untreated particleboard.

iv. Impacts of Cancellation

The price of the premixed penta solution purchased for the manufacture of treated particleboard is approximately $5.65 per gallon (McVey, 1980). Since there are no known alternative chemicals available for this use, no comparative prices were derived.

There is currently only one known producer of penta-treated particleboard. The applicator impacts of cancelling penta for this use would be limited to this plant.

On average, less than 1% of the total particleboard production of the plant during the last seven years was devoted to penta-treated particleboard (McVey, 1980). For the last several years, a gross annual revenue of about $35,000 was derived from the sale of the treated particleboard; the costs attributable to this gross figure are not known. Hence, the economic impacts of cancelling penta for this use would not be significant.

v. Limitations of Analysis

The Agency does not have data for a detailed analysis of the economic impacts to the users of penta-treated particleboard (e.g., cabinets or furniture makers). The Agency also lacks efficacy data to evaluate the monetary importance of penta-treated particleboard compared to untreated particleboard.

D. Summary of Wood Preservatives Economic Impacts

1. Introduction

Tables III-36 through III-40 summarize the usage and the potential economic impacts of cancellation of one, two or all three wood preservatives by use category and chemical for pressure and non-pressure applications. Table III-39 summarizes the short-term (e.g., first year) impacts from cancellation. Table III-40 summarizes the long-term average annual or annualized impacts (see Section III.B.4, Methods and Assumption, for definition).

2. Pressure Treatments

In general, the cancellation of one of the wood preservatives (e.g., cancel penta and retain all others) would result in few severe and long lasting economic impacts. Most economic impacts would generally be short in duration and related to the adjustment of the industry to alternate preservatives. Current trends in the wood treating industry are toward greater use of inorganic arsenicals since these have the most versatility of the wood preservative agents and are less dependent on petroleum and coal than either penta or creosote. The cancellation of two of the major wood preservatives with the retention of the third would result in severe economic impacts in certain cases such as railroad ties (cancellation of creosote and penta). For the majority of pressure treatment uses, however, the remaining alternative would be a viable substitute although cost impacts could be substantial for changing from one treatment process to another one.

On the other hand, the cancellation of all three wood preservatives would force the use of alternate building materials (e.g., concrete or steel) in-place of treated wood and would cause severe and long lasting economic impacts.

Creosote is the major wood preservative used for the treatment of railroad ties. The cancellation of creosote for this use would cause significant adverse long-term impacts. If penta remains available, the impacts will not be as severe as those generated if penta and creosote were not available. Copper naphthenate-treated or concrete ties (which are considerable more expensive than creosote- or penta-treated wood ties) would be the most likely alternatives under the penta and creosote cancellation scenario.

The lumber, timber and plywood uses are dominated by the inorganic arsenicals. With the exception of industrial block flooring (a creosote use), the inorganic arsenicals can possibly be used to treat all of the wood in this use category. There are many uses, moreover, for which inorganic arsenicals are the only viable preservative and creosote and penta are unacceptable. Thus, if penta and/or creosote were cancelled for lumber, timber and plywood uses, the economic impacts would not be severe. However, the cancellation of the inorganic arsenicals for these uses would cause adverse, large and long lasting, impacts with the substitution of non-wood materials (e.g., steel, aluminum, plastic, etc.). The economic impacts resulting from the cancellation of all three major wood preservatives cannot be determined because of the diversity of end-uses of lumber, timber and plywood, but these non-wood materials would be higher in cost than treated wood. The alternatives would also not have the performance (e.g., the ability to be reformed if needed) of treated wood.

Creosote is the major wood preservative used for the treatment of pilings. Penta cannot be used for marine pilings and hence the cancellation of creosote and inorganic arsenicals for the use of treating wood pilings would cause adverse impacts and would result in the use of more expensive concrete or steel pilings. For foundation pilings, if one or two of the three wood preservatives were cancelled, the long-term impacts are not projected to be substantial as long as one preservative remains available.

Penta is the major wood preservative used for the treatment of posts. All three of the major wood preservatives and steel posts can be used satisfactory and have comparable prices. The cancellation of one or two of the three wood preservatives in this use category would cause adverse short-term impacts due to the cost impact of the conversion from one treatment process to another.

TABLE III-36 Summary of Creosote Usage for Pounds of Active Ingredient Used and Amount of Wood Treated, 1978

Use Category	Pounds[a] (1,000)	Percentage	Cubic Feet[a] (1,000)	Percentage
1. Railroad ties	825,104	60.8	103,138	70.3
2. Lumber, timber and plywood	184,821	13.6	10,780	7.3
3. Pilings	151,733	11.2	9,993	6.8
4. Posts	27,504	2.0	4,584	3.1
5. Crossarms	398	<0.1	41	0.0
6. Poles	164,133	12.1	18,237	12.3
7. Poles-Groundline	655	<0.1	--	--
8. Home and farm	2,000	0.1	--	--
9. Sapstain control	--	--	--	--
10. Millwork and plywood	--	--	--	--
11. Particleboard	--	--	--	--
Total	1,356,348	100.0	146,773	100.0

a. Source: USDA-States-EPA, 1980.

TABLE III-37 Summary of Inorganic Arsenicals Usage for Pounds of Active Ingredient Used and Amount of Wood Treated, 1978

Use Category	Pounds[a] (1,000)	Percentage	Cubic Feet[a] (1,000)	Percentage
1. Railroad ties	--	--	2,498[b]	2.9
2. Lumber, timber and plywood	34,985	86.2	73,318	86.0
3. Pilings	1,392	3.4	943	1.1
4. Posts	1,784	4.4	4,461	5.2
5. Crossarms	12	0.0	29	<0.1
6. Poles	2,423	6.0	4,038	4.7
7. Poles-Groundline	--	--	--	--
8. Home and farm	--	--	--	--
9. Sapstain control	--	--	--	--
10. Millwork and plywood	--	--	--	--
11. Particleboard	--	--	--	--
Total	40,596	100.0	85,287	100.0

a. Source: USDA-States-EPA, 1980.

b. Inorganic arsenical-treated ties are not used for railroads. However, inorganic arsenical-treated ties are used for landscaping purposes and are considered under the use category of lumber, timber and plywood.

TABLE III-38 Summary of Penta Usage for Pounds of Active Ingredient Used and Amount of Wood Treated, 1978

Use Category	Pounds[a] (1,000)	Percentage	Cubic Feet[a] (1,000)	Percentage
1. Railroad ties	180	0.5	449	0.14
2. Lumber, timber and plywood	9,883	26.7	21,209	6.65
3. Pilings	692	1.9	1,154	0.36
4. Posts	3,295	8.9	10,983	3.44
5. Crossarms	646	1.7	1,615	0.50
6. Poles	18,857	50.9	41,905	13.13
7. Poles-Groundline	172	0.5	--	--
8. Home and farm	1,600	4.3	--	--
9. Sapstain control	1,016	2.7	3,580,000 board feet or 238,667 cubic feet	74.79
10. Millwork and plywood	650	1.7	33,000 board feet or 2,200 cubic feet and 15,000 square feet or 937.5 cubic feet	0.98
11. Particleboard	10	0.1	170 square feet or 10.625 cubic feet	<0.01
Total	37,001	100.0	319,130.125	100.0

a. Source: USDA-States-EPA, 1980.

TABLE III-39 First Year Impacts of Cancelling Wood Preservatives

Use Category	Economic Impact Extent	Significance
1. Railroad ties		
a. Cancel Creosote	decline in cost of $18.2 million[a]	minor
b. Cancel Penta	little or no impact	minor
c. Cancel Creosote and Penta	additional cost of $581 million to $3.7 billion[b]	major
2. Lumber, timber, and plywood		
a. Cancel Inorganic Arsenicals	significant losses, penta and creosote are not alternatives for most uses	major
b. Cancel Penta	additional cost of $18 million for preservatives and capital investment	major
c. Cancel Creosote	additional cost of $39 million	minor[c]
d. Cancel Inorganic Arsenicals and Penta	significant losses, creosote would not be a substitute in most uses	major
e. Cancel Inorganic Arsenicals and Creosote	significant losses, penta is not a substitute for most uses	major
f. Cancel Penta and Creosote	additional cost of $5.2 million	moderate[d]
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of non-wood materials were possible	major

TABLE III-39 First Year Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
3. Pilings		
a. Cancel Creosote	additional cost of $9 million to $10 million	major
b. Cancel Penta	additional cost of $8.3 million to $9.0 million	major
c. Cancel Inorganic Arsenicals	small impact, creosote would substitute for inorganic arsenicals	minor
d. Cancel Creosote and Penta	additional cost of $8 million[e]	major
e. Cancel Creosote and Inorganic Arsenicals	significant losses, 4.3 million cubic feet of marine pilings would be replaced with concrete or steel pilings	major
f. Cancel Penta and Inorganic Arsenicals	additional cost of greater than $9 million[f]	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	additional average annual cost of $64.5 million to $129.1 million	major
4. Posts		
a. Cancel Penta	additional cost of $0.75 million to $5.1 million	moderate
b. Cancel Creosote	additional cost of $3.3 million	moderate
c. Cancel Inorganic Arsenicals	additional cost of $4.0 million to $4.5 million	moderate
d. Cancel Penta and Creosote	additional cost of $383,000	minor

TABLE III-39 First Year Impacts of Cancelling Wood Preservatives (continued)

	Economic Impact	
Use Category	Extent	Significance
4. Posts (continued)		
e. Cancel Penta and Inorganic Arsenicals	additional cost of greater than $5.1 million	moderate
f. Cancel Creosote and Inorganic Arsenicals	additional cost of greater than $7 million	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of steel fence post were possible	major
5. Crossarms		
a. Cancel Penta	decline in cost of $0.23 million to an additional cost of $1.2 million	minor to moderate
b. Cancel Creosote	decline in cost of $15,000 to $30,000[g]	minor
c. Cancel Inorganic Arsenicals	small additional cost to alternate preservatives[g]	minor
d. Cancel Penta and Creosote	small decline in cost	minor
e. Cancel Penta and Inorganic Arsenicals	additional cost of $1.2 million	moderate
f. Cancel Creosote and Inorganic Arsenicals	decline in cost of $0.2 million[g]	minor
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of non-wood materials (e.g., steel) were possible	major
6. Poles		
a. Cancel Penta	additional cost of $19.9 million to $24.2 million	major
b. Cancel Creosote	additional cost of $9.4 million to $20.7 million	major

TABLE III-39 First Year Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
6. Poles (continued)		
c. Cancel Inorganic Arsenicals	additional cost of $1.9 million	minor
d. Cancel Penta and Creosote	additional cost of $28 million	major
e. Cancel Penta and Inorganic Arsenicals	additional cost of $35.5 million	major
f. Cancel Creosote and Inorganic Arsenicals	additional cost of $24.3 million	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of steel and concrete at higher cost	major
7. Poles-Groundline		
a. Cancel Creosote	small impact, substitution of penta	minor
b. Cancel Penta	small impact, substitution of creosote	minor
c. Cancel Creosote and Penta	decline in cost of $10 million to $12 million	minor
8. Home and farm		
a. Cancel Creosote	slight additional cost for preservative	minor
b. Cancel Penta	slight additional cost for alternatives	minor[h]
c. Cancel Creosote and Penta	slight additional cost for alternatives	minor[h]
9. Sapstain control		
Cancel Na-penta	cost and efficacy of Na-tetra is equal to that of Na-penta	minor[i]

TABLE III-39 First Year Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	 Significance
10. Millwork and plywood		
Cancel Penta	slight additional cost for alternatives	minor[j]
11. Particleboard		
Cancel Penta	$35,000 loss in revenues	minor[k]

a. Installation cost are lower for penta ties.

b. Both creosote and penta are cancelled and shifted to a copper naphthenate-treated or concrete tie system.

c. About 700,000 cubic feet of industrial block flooring cannot be treated with penta and/or inorganic arsenicals.

d. About 700,000 cubic feet of industrial block flooring and 4,258 cubic feet of transportation lumber that is currently treated with creosote cannot be treated with inorganic arsenicals.

e. Under this scenario, the high cost increase for equipment changes is largely offset by the lower cost of inorganic arsenical-treated pilings.

f. The cancellation of both penta and the inorganic arsenicals results in an economic impact similar to that of cancelling either penta or the inorganic arsenicals singly due to the high usage of creosote-treated pilings.

g. Economic impacts are only for current preservative prices and no additional investment cost for conversion from one preservative treatment process to another.

h. Penta provides better protection than alternatives and is more versatile than other wood preservatives.

i. The substitution of other alternatives (e.g., Cu-8 and tetra, Cu-8) would increase cost slightly, but these alternatives may not provide adequate protection as that of Na-penta for sapstain control.

j. However, the TBTO will only provide protection for above ground use when painted and the water-based Cu-8 product does not have the field use experience as that of penta for all exposure situations.

k. There are no chemical alternatives that are registered for this use of penta, but the comparative efficacy between penta-treated and untreated particleboard or chemically treating the finish particleboard once in service is unavailable.

TABLE III-40 Long-Term Impacts of Cancelling Wood Preservatives

Use Category	Economic Impact Extent	Significance
1. Railroad ties		
a. Cancel Creosote	additional average annual cost of $40.5 million	minor
b. Cancel Penta	little or no impact	minor
c. Cancel Creosote and Penta	additional average annual cost of $2.4 billion to $0.74 billion[a]	major
2. Lumber, timber, and plywood		
a. Cancel Inorganic Arsenicals	significant losses, penta and creosote are not alternatives for most uses	major
b. Cancel Penta	additional cost of $18 million for preservatives and capital investment	major
c. Cancel Creosote	additional cost of $39 million	minor[b]
d. Cancel Inorganic Arsenicals and Penta	significant losses, creosote would not be a substitute in most uses	major
e. Cancel Inorganic Arsenicals and Creosote	significant losses, penta is not a substitute for most uses	major
f. Cancel Penta and Creosote	additional cost of $5.2 million	moderate[c]
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of non-wood materials were possible	major
3. Pilings		
a. Cancel Creosote	additional cost of $9 million to $10 million	major

TABLE III-40 Long-Term Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
3. Pilings (continued)		
b. Cancel Penta	additional cost of $8.3 million to $9.0 million	major
c. Cancel Inorganic Arsenicals	small impact, creosote would substitute for inorganic arsenicals	minor
d. Cancel Creosote and Penta	additional cost of $8 million[d]	major
e. Cancel Creosote and Inorganic Arsenicals	significant losses, 4.3 million cubic feet of marine pilings would be replaced with concrete or steel pilings	major
f. Cancel Penta and Inorganic Arsenicals	additional cost of greater than $9 million[e]	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	additional average annual cost of $64.5 million to $129.1 million	major
4. Posts		
a. Cancel Penta	additional cost of $0.75 million to $5.1 million	moderate
b. Cancel Creosote	additional cost of $3.3 million	moderate
c. Cancel Inorganic Arsenicals	additional cost of $4.0 million to $4.5 million	moderate
d. Cancel Penta and Creosote	additional cost of $383,000	minor
e. Cancel Penta and Inorganic Arsenicals	additional cost of greater than $5.1 million	moderate

TABLE III-40 Long-Term Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
4. Posts (continued)		
f. Cancel Creosote and Inorganic Arsenicals	additional cost of greater than $7 million	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of steel fence post were possible	major
5. Crossarms		
a. Cancel Penta	decline in cost of $0.23 million to an additional cost of $1.2 million	minor to moderate
b. Cancel Creosote	decline in cost of $15,000 to $30,000[f]	minor
c. Cancel Inorganic Arsenicals	small additional cost to alternate preservatives[f]	minor
d. Cancel Penta and Creosote	small decline in cost	minor
e. Cancel Penta and Inorganic Arsenicals	additional cost of $1.2 million	moderate
f. Cancel Creosote and Inorganic Arsenicals	decline in cost of $0.2 million[f]	minor
g. Cancel Inorganic Arsenicals, Penta, and Creosote	significant losses, substitution of non-wood materials (e.g., steel) were possible	major
6. Poles		
a. Cancel Penta	decline in the average annual cost of $43.6 million to an additional cost of $32.8 million	major[g]
b. Cancel Creosote	decline in the average annual cost of $43.6 million to an additional cost of $17.8 million	major[g]
c. Cancel Inorganic Arsenicals	additional average annual cost of $17.8 million to $32.8 million	major

TABLE III-40 Long-Term Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
6. Poles (continued)		
d. Cancel Penta and Creosote	decline in the average annual cost of $43.6 million	major[g]
e. Cancel Penta and Inorganic Arsenicals	additional average annual cost of $32.8 million	major
f. Cancel Creosote and Inorganic Arsenicals	additional average annual cost of $17.8 million	major
g. Cancel Inorganic Arsenicals, Penta, and Creosote	additional average annual cost of $1.3 billion to $2.06 billion	major
7. Poles-Groundline		
a. Cancel Creosote	small impact, substitution of penta	minor
b. Cancel Penta	small impact, substitution of creosote	minor
c. Cancel Creosote and Penta	additional average annual cost of $35.3 million to $70 million	major
8. Home and farm		
a. Cancel Creosote	slight additional cost for preservative	minor
b. Cancel Penta	slight additional cost for alternatives	minor[h]
c. Cancel Creosote and Penta	slight additional cost for alternatives	minor[h]
9. Sapstain control		
Cancel Na-penta	cost and efficacy of Na-tetra is equal to that of Na-penta	minor[i]
10. Millwork and pylwood		
Cancel Penta	slight additional cost for alternatives	minor[j]

TABLE III-40 Long-Term Impacts of Cancelling Wood Preservatives (continued)

Use Category	Economic Impact Extent	Significance
11. Particleboard		
Cancel Penta	$35,000 loss in revenues	minor[k]

a. Both creosote and penta are cancelled and shifted to a copper naphthenate or concrete tie system.

b. About 700,000 cubic feet of industrial block flooring cannot be treated with penta and/or inorganic arrsenicals.

c. About 700,000 cubic feet of industrial block flooring and 4,258 cubic feet of transportation lumber that is currently treated with creosote cannot be treated with inorganic arsenicals.

d. Under this scenario, the high cost increase for equipment changes is largely offset by the lower cost of inorganic arsenical-treated pilings.

e. The cancellation of both penta and the inorganic arsenicals results in an economic impact similar to that of cancelling either penta or the inorganic arsenicals singly due to the high usage of creosote-treated pilings.

f. Economic impacts are only for current preservative prices and no additional investment cost for conversion from one preservative treatment process to another.

g. Even though there is a long-term decline in the average annual cost of $43.6 million for the users of treated wood poles, the short-term (e.g., first year) impact to the applicators is major (an increase cost from $9.4 million to $28.0 million) for additional capital investment for conversion from one perservative treatment process to another.

h. Penta provides better protection than alternatives and is more versatile than other wood preservatives.

i. The substitution of other alternatives (e.g., Cu-8 and tetra, Cu-8) would increase cost slightly, but these alternatives may not provide adequate protection as that of Na-penta for sapstain control.

j. However, the TBTO will only provide protection for above ground use when painted and the water-based Cu-8 product does not have the field use experience as that of penta for all exposure situations.

k. There are no chemical alternatives that are registered for this use of penta, but the comparative efficacy between penta-treated and untreated particleboard or chemically treating the finish particleboard once in service is unavailable.

Penta is the major wood preservative used for the treatment of crossarms. Each of the three major wood preservatives is satisfactory for this use and long-term impacts are not projected as long as one of the major wood preservatives is available. If penta were cancelled, major conversion impacts could be experienced. If all three wood preservatives were cancelled, there would be adverse impacts due to the use of higher cost of steel crossarms, and there would be adverse impacts dut to the associated conversion costs for treating other wood products (e.g., poles, pilings, etc.) with other wood preservatives.

All three wood preservatives are used for the treatment of poles and each could substitute for the other for this use. There are few long-term impacts expected from the cancellation of one or two of these chemicals. There are, however, significant short-term adjustment impacts which would be associated with the conversion from one preservative treatment process to another. If all three wood preservatives were cancelled, there would be major impacts resulting from the forced conversion by pole users to alternate materials (e.g., steel and concrete).

3. Non-pressure Treatments

The cancellation of penta and/or creosote for non-pressure applications (e.g., home and farm, millwork and plywood, and sapstain control uses) would generally result in the substitution of alternate wood preservatives at substantially higher cost to the applicator. Also, most of the alternatives can only be considered partial substitutes, specifically for penta.

Continuation of poles-groundline treatment is dependent upon the availability of either creosote or penta. If one of these preservatives is unavailable, it will be replaced by the other for this use. Cancelling both creosote and penta for poles-groundline treatment would result in a shorter useful service life of the poles; requiring more frequent replacements of treated poles and increasing the average installed cost for distribution poles between $77.8 million to $156 million annually at current prices beginning 5 and 10 years after poles-groundline cancellation, respectively.

The alternative wood preservatives for home and farm use are limited to specific conditions of end-use of the treated wood product. Penta can replace creosote, but creosote can be considered only a partial substitute for penta. Penta is unique in its ability to leave a clear finish on wood and provide excellent protection for the wood used aboveground and limited protection below ground. Two of the alternatives (e.g., TBTO and zinc naphthenate) provide a clear, paintable surface, but do not afford the protection that penta does.

Cancelling Na-penta for sapstain control would result in serious economic losses to the lumber industry without the use of alternative preservatives. If Na-penta were cancelled for sapstain control, many applicators would most likely switch to Na-tetra which is equally efficacious and of equal cost. Although effective, TCP is more costly for a registrant to formulate and, therefore, its use by applicators may only increase slightly. Another possible alternative for sapstain control is Cu-8, although Cu-8's performance under extreme conditions is not believed to be adequate. There would be minor changes in treatment cost if an applicator switches from Na-penta to one of the above chemical alternatives for sapstain control.

Millwork and plywood require a wood preservative that is colorless, compatible with paints, stains, sealers and primers, and does not interfere with the adhesion of glazing compounds (e.g., caulkings or other sealants). The alternatives do provide protection for millwork under most conditions, but they do not equal the protection provided by penta.

If penta were cancelled for millwork and plywood treatments, applicators would most likely switch to a 0.75% TBTO solution which is similar in cost to penta and has shown effectiveness for aboveground exposure when painted, but not for below ground exposure. If the water-based Cu-8 solution proves its effectiveness, many applicators would switch from penta to Cu-8.

There are no chemical alternatives for penta used in the manufacturing of treated particleboard. The quantity of treated particleboard produced is small and the economic losses would be small, but a unique product would no longer be available if penta were cancelled for this use.

IV. DEVELOPMENT OF REGULATORY OPTIONS

A. Introduction

In Parts II and III, the Agency identified the risks and benefits of the uses of the wood preservatives under review. As explained in Part I, FIFRA requires the Agency to determine if the use of a pesticide meets the statutory standard for registration by balancing the risks and the benefits of use. To carry out this mandate, the Agency has developed a range of regulatory measures which are intended to reduce the risks of use for the pesticides under review. This Part discusses the factors which have been taken into account in developing the regulatory options for the wood preservatives and describes in detail those measures selected for further consideration in Part V.

B. Basis and Rationale for Developing Options and Modifications

There are three basic options for regulating all pesticides:

Option 1 - Continuation of Registration without changes
Option 2 - Continuation of Registration with Modifications to the Terms and Conditions of Registration
Option 3 - Cancellation of registration

The two extreme options, Option 1, Continuation of Registration without change and Option 3, Cancellation of registration, are at the opposite ends of the risk/benefit spectrum. Adoption of

Option 1 would be appropriate when the Agency has concluded that the level of risk is acceptable in light of the pesticide's benefits and that further risk reduction measures are not necessary to assure that the use of the pesticide meets the statutory standard for continued registration.

Adoption of Option 3, Cancellation, would be appropriate when the Agency has concluded that the risks from a use outweigh the benefits of that use, and that these risks cannot be mitigated to an acceptable level, in light of the benefits, by any other measures short of cancellation. Cancellation prohibits the sale or the distribution of a pesticide for a particular use or uses. The effect of cancellation is to entirely eliminate the risks of a pesticide's use or uses as well as the benefits. Cancellation may affect all uses of a compound, or it may affect only specific uses (such as, for example, railroad ties, or posts, or sapstain control), or specific formulations (for instance powders, liquids, or high concentrations), or specific application methods (for instance, spray, dip, or brush-on).

The middle option, Option 2, is appropriate when the risks of a pesticide use can be reduced to an acceptable level, while preserving the benefits of the use. This risk reduction is accomplished by modifying the terms and conditions of the pesticide's registration. These modifications, which are expressed through the pesticide's labeling are, for the most part, changes in the way the pesticide is used. These changes are designed to reduce exposure to the pesticide, and thereby reduce or even eliminate the risk from the pesticide.

C. Discussion of Option 2, Modifications to the Terms and Conditions of Registration

Various considerations were involved in the selection process for the Option 2 modifications, namely the effectiveness of the measures in reducing exposure, the practicality and enforceability of the measures, and the cost impact of their implementation. A number of measures were considered but rejected on the grounds of limited risk reduction capability, technical infeasibility, unenforceability, lack of statutory authority or impracticality. Appendix 2 lists possible modifications which were rejected from further consideration for the reasons given above.

The specific risk reducing modifications which the Agency has selected for further consideration are presented in the following section. For each modification, the discussion focuses on 1) the objective which the modification would accomplish, 2) the specific preservatives and uses to which the modification pertains, 3) the particular risks to affected populations which would be reduced, and 4) the practicality of the modification.

a. Require Protective Clothing: Gloves

This modification would require applicators to wear gloves made of material resistant to the wood preservative while handling treated wood. Gloves would also be required when mixing the wood preservative, and when cleaning and maintaining treatment equipment, such as pressure cylinders, spray-boxes, soak tanks, and other equipment in industrial situations. Applicators would also wear gloves when cleaning equipment, such as brushes. This protective clothing modification would apply to all use categories and all applicators. When handling treated lumber or applying the preservative solutions, the primary site of dermal exposure is the hands. Although adequate experimental data are not available on the permeability of gloves to these wood preservatives, the Agency estimates that appropriate gloves will reduce dermal exposure through the hands by 99% in most situations. This reduction assumes no pesticide penetration through the gloves, and a small possibility of some exposure around the cuff (Kozak, 1980).

Also, during the mixing of inorganic arsenicals and sodium penta powder or prilled (penta) formulations, gloves would provide some reduction of total dermal exposure. The reduction in dermal exposure, based on the reduction of skin area available to absorb the pesticide, is about 30% (Kozak, 1980).

b. Require Protective Clothing: Coveralls

This modification would require applicators who manually empty bags or mix powder formulations to wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing during emptying and mixing operations. Since creosote is not formulated as a powder, this modification would apply only to powder formulations of the inorganic arsenical compounds and to prilled penta and prilled or powder sodium penta. Furthermore, since such powder formulations are used only in industrial situations, this modification would apply only to commercial uses of these wood preservatives.

Commercial applicators would also be required to wear disposable coveralls during brush-on applications of these pesticides. Homeowners would be required to wear tightly-woven long sleeved cotton coveralls during brush-on applications of these pesticides since the homeowners will not have easy access to disposable coveralls.

This modification would reduce applicators' dermal exposure to wood preservative dust. The protected areas would be the forearms, neck, and chest. If uncovered skin areas were protected during these operations (including skin covered by gloves), reduction in total dermal exposure would be about 80%, based on the reduced skin area available to absorb the pesticide (Kozak, 1980).

c. Require Protective Clothing: Neoprene Suit and Respirators

This modification would require that applicators or other personnel manually cleaning or entering treatment cylinders and vats, and applicators performing other high exposure tasks wear neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a respirator. For some situations, only the respirator and gloves would be proposed, since the exposure involved is not sufficently large to require complete isolation from the environment. This equipment would, in effect, almost completely isolate the wearers from an environment where high exposure can occur.

Proper use of respirators and this type of protective clothing would be expected to reduce the high dermal and inhalation exposure during the maintenance (e.g., cleaning or repairing) of treatment equipment, during specific commercial applications (e.g., spraying of solutions and mixing powder formulations) and while opening treatment cylinder doors. The use of a rubberized protective suit consisting of an overall, jacket, gloves and boots would be expected to reduce potential dermal exposure to solutions by about 80%, based on the reduced skin area available to absorb the pesticide. The use of a half-mask canister or cartridge respirator capable of trapping pesticide particulates and vapors would reduce potential inhalation exposure by about 90% (Kozak, 1980). Most treatment plants already recommend that protective clothing and respirators be worn during the maintenance and cleaning of treatment equipment. However, most labels do not currently state that protective clothing and equipment should be used during these operations.

d. Require Protective Clothing: Dust Masks

This modification would require applicators or other personnel working outdoors in treatment plants which use the inorganic arsenical wood preservatives to wear a dust mask.

The air concentrations of arsenic are about the same throughout treatment plants (the only exceptions are in those areas for which a respirator will be required; see modification 2.c). This modification would reduce the inhalation exposure by about 80% for workers in these industrial situations (Kozak, 1980).

e. Require Care of Protective Clothing

This modification would require that applicators and other personnel leave all protective clothing and equipment (e.g. respirators) as discussed in modifications a through d, at the treatment plant at the end of the workday. This modification would also require that work shoes be left at the treatment plant and that worn out protective clothing be disposed of by following pesticide container disposal. This modification would apply to all industrial uses of all three wood preservatives.

If adopted, this modification would greatly reduce or eliminate a source of wood preservative exposure in treatment plant workers' homes. The exposure to the workers would be reduced to some extent, and the exposure to the workers' families would be nearly eliminated. Leaving protective clothing and equipment at the treatment plant is already an accepted good work practice. At those treatment plants surveyed, 75% of the workers' work shoes are already left at the treatment plant on a required or voluntary basis (Mitre, 1980).

f. Prohibit Eating, Drinking and Smoking During Application

This modification would require that applicators and other personnel not eat, drink or smoke in the treatment area. It would also prohibit home and commercial applicators from eating, drinking or smoking when they are applying these wood preservatives. This modification would apply to all use categories of all three wood preservatives. If adopted, this modification would reduce treatment plant workers' and other professional treaters' oral exposure to the wood preservatives and would greatly reduce the opportunity for accidental ingestion of these pesticides by homeowners.

Many treatment facilities already have designated eating areas. This amendment is considered to be a standard good work practice for all plants working with chemicals and is noted, for example, in the Occupational Safety and Health Standards, 29 CFR 1910.141(g). In addition, it is a standard practice in pesticide labeling to caution against eating, drinking, or smoking during pesticide application.

g. Confine Emptying Bags and Mixing of Powder and Prilled Formulations to Closed Systems.

This modification would reduce air levels of the powder or prilled formulations by requiring any of numerous technologies to be used during mixing and emptying of bags or other containers. In an example of a closed system, powder formulations are unloaded by pneumatic systems from a hopper truck or railroad car directly into the dissolving tank, which is also a closed system. This type of system greatly reduces applicators' exposure. However, in a number of small wood treatment plants, the applicators open and empty prilled formulations of penta, prilled and/or powder formulations of sodium penta or powder formulations of inorganic arsenicals by hand into the dissolving tanks. This open system of handling these formulations poses a high degree of dermal and inhalation exposure to the applicator.

This modification would limit the amount of airborne pesticide powder in the mixing room, by one or more of several methods, and thereby reduce the applicators' exposure. The modification, if adopted, would affect only prilled and powder formulations of penta and sodium penta and the inorganic arsenical compounds for use in industrial situations. (As noted there are no creosote powder formulations.)

h. Classify for Restricted Use

This modification would restrict all the wood preservative compounds of concern to use by certified applicators only.

Under FIFRA, hazardous pesticides may be classified for restricted use and be limited to use only by or under the direct supervision of certified applicators. To become certified, the applicators must enroll in a certification program, which teaches the safe use of restricted use pesticides. Upon completion of these programs, the applicators are certified for a particular restricted use pesticide or pesticides.

Classification for restricted use would ensure that the wood preservatives would be available only for use by or under the direct supervision of trained applicators. By preventing untrained or unsupervised applicators from using these pesticides, the risk of human exposure due to misuse or carelessness would be significantly reduced. The classification of the wood preservatives as restricted use pesticides would not impose an undue burden since there are already many certified applicators and there is relatively little difficulty in obtaining applicator certification.

i. Restrict Application of Wood Preservatives to Outdoors and the Application of Wood Preservatives to Wood Destined for Interior Uses.

This modification would restrict the use of the wood preservatives to outdoor situations and would restrict the application of these products to wood destined for specific interior uses. Outdoor application is defined in FIFRA as any pesticide application or use that occurs outside enclosed man-made structures or the consequences of which extend beyond enclosed man-made structures.

Adoption of this modification would eliminate the applicator's inhalation exposure during applications of the preservative in enclosed structures. This modification would also eliminate the inhalation exposure for those people who build enclosed structures with treated wood or those individuals who live in enclosed structures made of treated wood.

j. Prohibit Uses Likely to Result in Direct Exposure to Domestic Animals or Livestock on in the Contamination of Food, Feed, or Potable Water

This modification would prohibit the applicator from using any of the wood preservatives in a manner which is likely to result in direct exposure to domestic animals or livestock or in the contamination of food, feed, or potable water. Such sites include, but are not limited to, vegetable and fruit stakes, mushroom flats, feed lot bins, watering and feed troughs, seed flats, animal bedding and pens, irrigation flumes, food container and similar items. This modification would apply to all three wood preservatives for all use categories.

Wood preservative residues in food arise from both wood and nonwood uses of these compounds. It is not known how much each use contributes to the dietary burden. However, the exposure to the general population would be reduced if these wood uses were prohibited.

k. Reduce Arsenic Surface Residues on Treated Wood

This modification would require applicators to use work practices or technologies which will reduce the arsenic surface residues on wood treated with the inorganic arsenical compounds. The modification was developed to deal with the concern that the inorganic arsenical wood preservatives can be absorbed through the skin and inhaled as dust or vapors from treated wood. It is intended to reduce the dermal and inhalation exposure for treatment plant applicators and workers in industrial situations. It would also reduce the dermal and inhalation exposure to people who use treated wood for construction purposes; moreover it would reduce the exposure to the general population from treated wooden structures such as park benches, playground equipment, picnic tables, and similar outdoor wooden structures.

There are two stages during the application process when solvent evaporation can result in arsenic surface residues on the treated wood. The first begins when the wood is removed from the treating cylinder and is still covered by a film of preservative solution. The second occurs after the surface film is dried. From the limited data available, at least several factors appear to be of critical importance in affecting the quantity of residues deposited on the surface of treated wood. These factors include wood surface conditions, fixation conditions, and draining mechanisms.

Although there is no standardized methodology for sampling the surface residues on arsenically treated wood, there are several reported process control technologies available to the applicators for reducing the amount of arsenic surface residues on treated wood. These technologies include starting with clean wood, maintaining clean treatment facilities, and draining excess treating solutions from the wood after treatment. Some specific control technologies capable of lowering the arsenic surface residues on treated wood are improved purity of copper in the treatment solutions, filtration of treatment solutions prior to use in the treatment cylinders, pH control of treatment solutions, an additional vacuum stage in the treatment process, sheds or other covers to protect the freshly treated wood from rainfall (allowing the preservative to become "fixed" in the wood), and post-treatment washing of each piece of treated wood (Mitre, 1980a).

Each of these control technologies has been used in at least one wood treatment plant. The only widely used control technology is filtration of the treatment solution. Although the reduction in arsenic residues achieved by the use of these technologies cannot be accurately quantified until a standardized sampling method becomes available, the Agency believes that significant reduction in residues will result from implementation of these specific technological measures during the application process.

1. Reduce Contaminants in Penta

This modification would reduce the level of the hexachlorodibenzo-p-dioxin (HxCDD) contaminant in all penta products. The HxCDD contaminant, which has been shown to be teratogenic and oncogenic in test animals, is formed in technical penta and sodium penta during the manufacturing process.

Although most technical penta products on the market contain about 15 ppm HxCDD, technical penta can be produced with as little as 1 ppm HxCDD (e.g., Dowicide EC-7). To reduce this source of exposure to the HxCDD contaminant in penta and sodium penta, the Agency will consider requiring that technical penta and sodium penta contain no more than 1 ppm HxCDD. By lowering the amount of HxCDD in technical penta and sodium penta, the exposure to HxCDD in all situtions would be reduced to about one-fifteenth of the present exposure. This reduction in exposure would reduce the risk by about one-fifteenth of the present risk.

A registered product, Dowicide EC-7, made by Dow Chemical Co., has lower dioxin contaminants than other registered technical grade penta products on the market. Dioxin levels were reduced in this product through alterations in the manufacturing process. Other companies could also presumably develop manufacturing processes to lower the level of dioxin contaminants in their products. The requirement for this reduction in contaminant level may, however, cause these companies to cease the manufacture of penta because of cost considerations.

D. Other Relevant Statutory Measures

A number of other statutes, either administered by EPA or other agencies, have a bearing on the regulation of the wood preservative agents. The relevant statutes and the authority they confer on wood preservative regulation are briefly discussed below.

1. Occupational Safety and Health Act

Under the authority of The Occupational Safety and Health Act, the Occupational Safety and Health Administration (OSHA) is responsible for promulgating and enforcing standards which will assure the occupational safety and health of employees. OSHA has stated that it will defer to this Agency's workplace regulation of the use and impregnation/application of wood preservatives (Whiting, 1979). This deferral will continue as long as OSHA has full assurance from this Agency of an active program to investigate any public or occupational health risks from these wood preservatives and full assurances that regulatory action to eliminate any significant risks also will be forthcoming from this Agency.

2. Toxic Substances Control Act

The Agency expects to propose certain regulatory measures concerning the use and handling of treated wood products under the authority of the Toxic Substances Control Act (TSCA). Currently, under the regulations issued pursuant to FIFRA, the Agency does not regulate end-use products, such as treated wood, where no pesticidal claims are made for the treated item itself. TSCA, however, has the authority to fill the regulatory gap and provide measures to regulate end-use products which contain a pesticide but which are not themselves pesticides.

Accordingly, the Agency is proceeding to implement regulations under TSCA to meet the Agency's concerns about exposure to and the effects of preservative-treated wood products. The Agency intends to request that the wood treatment industry and retailers of treated wood comply voluntarily with the proposed labeling measures which will require TSCA rulemaking. Concurrently, the Agency intends to initiate proposed rulemaking pursuant to Section 6 of the Toxic Substances Control Act (TSCA) to require adoption of these label measures.

To regulate under Section 6 of TSCA, the Agency must make a finding that there is a reasonable basis to conclude that the manufacturing, processing, distribution in commerce, use or disposal of a chemcial substance or mixture, or any combination of such activities, presents or will present an unreasonable risk of injury to health or the environment.

TCSA Section 6(a)(3) provides that the Agency can require that the products "be marked with or accompanied by clear and adequate warnings and instructions with respect to its use, distribution in commerce, or disposal or with respect to any combination of these activities." TSCA Section 6(a)(2) provides that the Agency can prohibit the processing or distribution in commerce of the product for a particular use. TSCA Section 6(a)(5) provides that the Agency can prohibit or otherwise regulate any manner or method of disposal of the product "by its manufacturer, processor, or by any other person who uses or disposes of it for commercial purposes." Under a combination of these authorities and methods, the Agency could accomplish the controls it believes are necessary to protect users of these treated products and the public at large.

At this time, the Agency anticipates that it will be able to make the findings necessary for the issuance of labeling information for preservative-treated wood products under Section 6 of TSCA and will be proposing a rule pursuant to TSCA. Such a rule would meet the purpose of TSCA by filling the gap in regulation of wood preservatives under FIFRA and allow treated wood products to be sold with adequate use information. This approach is consistent with the Agency's concern for regulatory flexibility and would preserve the benefits of wood preservatives while protecting the public health from the adverse effects of preservative-treated products. These TSCA precautionary labels, which would be distributed to the end-users of the treated, wood would recommend that: 1) All individuals who handle pesticide-treated wood wear gloves impervious to the wood preservatives, 2) Individuals who saw pesticide treated wood wear disposable coveralls, 3) Individuals who saw pesticide-treated wood and fabricate structures with treated wood wear a dust mask, 4) Treated wood can be used indoors for specific uses, 5) Treated wood not be used in a manner which may result in direct exposure to animals or in the contamination of food, feed, or water, and 6) Treated wood be disposed of by methods, such as on-site burial, which are in accordance with local and state laws, and the Resource Conservation and Recovery Act, rather than by burning.

3. Consumer Product Safety Act

Under the authority of the Consumer Product Safety Act, the Consumer Product Safety Commission (CPSC) has some regulatory jurisdiction pertaining to the consumer use of wood treated with pesticides; the CPSC, however, has not issued any pertinent regulations to date. If the CPSC promulgates regulations covering the wood treated with pesticides, TSCA will be preempted to the extent that the CPSC takes sufficient action to protect against the risk of concern.

4. Resource Conservation and Recovery Act

EPA also has authority under the Resource Conservation and Recovery Act of 1976 (RCRA) to control the disposal of preservative-treated wood products if the Agency determines that these wastes may pose a substantial hazard to human health and the environment, if improperly managed. Under Subtitle C of RCRA, a "cradle to grave" regulatory scheme for the management of hazardous waste is to be set-up.

According to the hazardous waste regulations promulgated on May 19, 1980, botton sediment sludge from the treatment of wastewaters resulting from creosote and/or pentachlorophenol wood preserving processes has been identified as hazardous. In addition, wastes which contain arsenical compounds may be hazardous if these wastes fail the EP toxicity characteristic test (see 40 CFR 261.24 for details). RCRA regulations specify general standards and procedures for the handling of hazardous waste; for the wood preservatives these wastes are generated from such sources as the manufacture of the wood preservatives, the expended material used in the wood treatment process, and the end-use of treated wood or wood products. Disposal for wastes which are generated in excess of 1,000 kg per month or wastes which accumulate in excess of 1000 kg over any time period is regulated under Subtitle C of RCRA*; smaller quantities have been exempted. It is likely that the end-use of these treated wood products will seldom exceed the 1,000 kg small quantity exemption; thus, RCRA will not control these wastes when generated in small quantities.

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* On November 25, 1980, EPA temporarily excluded from RCRA control arsenical-treated wood or wood products which are generated by persons who utilize such treated wood or wood products for the wood's intended end-use.

V. REVIEW OF THE IMPACTS OF REGULATORY OPTIONS AND MODIFICATIONS

A. Introduction

In the previous parts of this document, the Agency evaluated the risks and benefits of the wood preservatives (creosote, the inorganic arsenical compounds, and penta) and considered the regulatory means by which the risks might be reduced. The purpose of this part is to determine the most appropriate regulatory options and modifications for each use of the three wood preservatives. To accomplish this, the human and environmental risks of each use are compared with the benefits of the use. If this comparison shows that there are unreasonable adverse effects to man or the environment from current use patterns, various regulatory actions are developed to reduce the risks of those uses. The Agency then evaluates the extent to which these regulatory modifications will change the risks and benefits of each use. Finally, by comparing the changes in the risks and benefits, the Agency selects and proposes the most appropriate regulatory measures for each use.

There are three basic options: Option 1, the Continuation of Registration; Option 2, the Continuation of Registration with Modifications to the Terms and Conditions of Registration; and Option 3, Cancellation. If the Agency determines that a use of a wood preservative does not pose unreasonable adverse effects to man or the environment, then Option 1, the Continuation of Registration, will be the selected option for that use. If the

Agency determines that a use does cause unreasonable adverse effects in man or the environment, then the risk and benefit impacts of various modifications to the terms and conditions of registration will be considered. If the modifications singly, or in combination, do reduce the risks of a use to an acceptable level, then Option 2, the Continuation of Registration with Modifications to the Terms and Conditions of Registration, will be the selected option for that use. If these modifications, which are intended to reduce the risk of a pesticide's use while preserving benefits, do not reduce the risks to an acceptable level, then Option 3, Cancellation, will be the selected option for that use.

The pressure and non-pressure uses for which the wood is treated at treatment plants (i.e., railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, sapstain control, millwork and plywood, and particleboard) will be grouped together in the discussions of risks, benefits[*], and regulatory options. The risks, benefits, and regulatory options will then be discussed with regard to those uses for which the pesticides are applied outside of the treatment plant (i.e., poles-groundline, home and farm, and brush-on applications of the inorganic arsenicals) and finally, those uses of the wood after it is treated and has left the plant.

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[*] A use-by-use summary of the benefits is provided for the wood treated at plants.

For each use, or group of uses, this document will 1) summarize the risks of each pesticide (discussed at length in Part II), 2) summarize the benefits of each pesticide (developed at length in Part III), 3) consider the appropriate option by weighing the risks against the benefits for the use, including the impact of possible modifications to the terms and conditions of registration and, as a result of this analysis, 4) select the appropriate option (i.e., the Continuation of Registration, Modification to the Terms and Conditions of Registration, or Cancellation). If cancellation or continued registration without changes is not the selected option, the appropriate modifications to the terms and conditions of registration will be selected. Section V.E of this Part summarizes the Agency's selected options.

B. Use Categories: Pesticides Applied At Pressure and Non-Pressure Treatment Plants

All of the wood products in the use categories discussed in this section are treated at treatment plants. Railroad ties, lumber, timber and plywood, pilings, posts, crossarms, and poles are treated with pressure; sapstain control, millwork and plywood, and particleboard do not require pressure for treatment. The equipment for each type of treatment process is similar; pressure treatment processes employ pressure cylinders to apply and treat the wood with creosote, inorganic arsenicals and/or penta, while non-pressure treatment processes utilize primarily penta or sodium penta in open vats or spray operations for treatment. Therefore, for each specific activity in the treatment process with a particular pesticide, the risks to the applicator remain unchanged regardless of the end-use for which the wood is being treated. For example, an applicator opening a door of a cylinder containing creosote has the same health risk whether the wood being treated in that cylinder will be used as railroad ties, poles, fence posts, and/or other wood products. Therefore, to avoid repetition, the risks to a treatment plant worker will be grouped by treatment plant activities and by each chemical, rather than discussed on a use-by-use basis.

1. Summary of Risks

About 9,000 to 13,000 workers (10-50 per plant) are involved in the pressure treatment of wood using the three wood preservatives for the following uses: railroad ties, lumber, timber and plywood, pilings, posts, crossarms and poles. The number of workers applying creosote is about 4,000 to 1,400; about 1,400 to 2,000 workers are engaged in applying the inorganic arsenicals, and about 4,000 to 5,000 workers apply penta. The uses requiring the non-pressure treatment of wood involve the following work force in the treatment plant: sapstain control with sodium penta, about 20,000 workers (10 per plant); millwork and plywood with penta, 7,000 to 10,000 workers (3-5 per plant); and particleboard with penta, about 10 workers (only 1 plant involved).

All of these workers perform some aspect of pesticide application at these plants during the work day. For example, during the pressure treatment of wood with penta, one worker might be mixing the pesticide, while another might be removing the treated wood from a pressure cylinder. Each of these pesticide application activities is generally performed by 2 to 4 workers. Therefore, the Agency will consider all workers associated with the treatment process to be applicators regardless of their individual activities during the work day.

As discussed in Part II of this document, the Agency has estimated the risks to which the workers would be subjected during their individual activities in the treatment plant. The individual applicators receive a fixed level of exposure regardless of the final use of the treated wood.

The treatment plant activities where potential exists for high risk include entering pressure cylinders, opening cylinder doors following treatment, and emptying bags and mixing powder or prilled formulations. The other generalized treatment plant activities which have been considered in evaluating the risks of these pesticides include exposure to background (ambient) air levels in the plants, handling treated wood, and specific spraying and dipping processes. While the individual activities are similar for the three preservatives, the risks associated with the use of the individual preservatives in these situations vary both in the nature and in the magnitude of the health effects.

In terms of comparative risks from the application of these chemicals in the treatment plants, penta has a lower fetotoxic margin of safety than the inorganic arsenicals, while the inorganic arsenicals have greater oncogenic risks than penta for the treatment plant activities. While creosote poses an oncogenic risk, the magnitude of this risk has not been quantified due to a lack of data, and hence no direct comparison between creosote and the other two wood preservatives can be made. However, the Agency has no information to indicate that the risks from exposure to creosote are less than the risks from penta or inorganic arsenical exposure. All of the wood preservatives pose high risks for treatment plant applicators under current labeling and use patterns. Discussion, by chemical, of the specific exposure situations and their associated risks follows.

a. Creosote

As discussed in Sections II.B.5 and II.B.6, creosote poses oncogenic and mutagenic risks to humans. These risks have not been quantified since there are very little data available regarding treatment plant workers' exposure to all of the specific oncogenic or mutagenic components of creosote. However, the large number of animal studies, supported by the human case studies, indicate that a finite risk to treatment plant workers exists.

i. Background Creosote Air Levels

The Agency has inadequate information regarding the total oncogenic or mutagenic components of creosote in the ambient air to which workers involved in the general operations around a plant are exposed. Consequently, the risks resulting from this exposure have not been quantified. However, the Agency does expect these workers will generally be exposed to the more volatile, lower molecular weight components of creosote.

ii. Bag Emptying

Because creosote is not prepared from a powder formulation, discussion of this activity is not applicable with regard to potential risk.

iii. Mixing Concentrated Solutions and Handling Diluted Solutions

The Agency recognizes that much of the preparation of working solutions of creosote by dilution from concentrated solutions is performed automatically in mixing tanks. Because no exposure to creosote is anticipated during this procedure, discussion of the potential risk while mixing concentrated solutions and handling diluted solutions is not applicable.

iv. Opening Cylinder Door

Although the Agency has no quantitative data demonstrating that workers involved in the opening of cylinder doors following treatment are exposed to the oncogenic or the mutagenic components of creosote, the Agency believes that there is exposure to some finite amount of these components as explained in Section II.B.4, and hence a resultant risk.

v. Handling Treated Wood

Treatment plant workers' dermal exposure to creosote occurs during the manual handling of the wood that is still wet with creosote treatment solution. While many plants have automated or mechanical equipment to handle the freshly treated wood, some may not have such equipment. Due to a lack of data, the Agency is unable to determine the lifetime oncogenic risk to the handlers of wood which has been freshly treated with creosote, but believes that there is some degree of exposure and hence a resultant risk.

vi. Entering the Cylinders

While entering a cylinder for manual cleaning or for any other purpose (e.g., releasing a wood jam), the applicator may experience dermal exposure to the creosote treatment solution through contact with unprotected areas of skin and through inhalation of vapors. While the Agency cannot quantitatively estimate the exposure to the treatment plant worker resulting from this activity because of a lack of data, the Agency believes that there is some degree of risk.

b. Inorganic Arsenical Compounds

The Agency has determined that wood treatment plant applicators face serious health hazards as a result of exposure to the inorganic arsenical compounds or arsenically treated wood. These health hazards include oncogenic, teratogenic and fetotoxic effects. Mutagenic damage and possible delayed neurotoxic effects from arsenic have been demonstrated; however, these effects have not been quantitatively estimated. The risks to the treatment plant workers, who are applying the inorganic arsenical products, result from dermal and inhalation exposure during several pesticide application activities.

i. Background Arsenic Air Levels

The Agency has determined that the "time weighted average" of the background (ambient) arsenic air levels in treatment plants is 70 ug/m^3, which corresponds to 10 ug/kg/day inhalation exposure. The inhalation exposure to dust containing arsenic is greatly enhanced by the stacks of arsenically treated wood drying in the treatment plant yards. Dust is produced when the treatment solution leaches, dries, and flakes from the surface of the drying stacks of freshly treated wood. Small particles are inhaled as dust and are absorbed in the lung, while larger particles are ingested and are absorbed in the gastrointestinal tract. Based on these air arsenic levels, the Agency estimates that the teratogenic/fetotoxic margin of safety (MOS) is 500. The total lifetime oncogenic risk from the background arsenic air levels in the plant is estimated to be 1.9×10^{-2}. Although the Agency has not quantitatively estimated the treatment plant workers' risk of mutagenic damage, the Agency believes that the mutagenic risk potential is high.

ii. Bag Emptying

Treatment plant workers who empty bags containing inorganic arsenical powder formulations in the preparation of the treatment solutions contact arsenic dust via the skin. The amount of inhaled arsenic-containg dust is also increased over background levels as a result of this activity. The Agency assumes that all ambient dust resulting from bag emptying will be respirable and will reach the lungs, rather than the gastrointestinal tract, due to the small particle size. The Agency estimates that the total daily dose from this activity is 17 ug/kg/day, resulting in a teratogenic/fetotoxic MOS of 294 and a lifetime oncogenic risk of 3.4×10^{-2}. This oncogenic risk is composed of dermal and inhalation components. The risk of skin cancer to an individual, which is primarily related to the dermal exposure component, is estimated to be 6.0×10^{-3}. The risk of lung cancer to an individual is primarily related to a combination of background (ambient) arsenic dust in the plant and the dust resulting from the bag emptying; this risk is estimated to be 2.8×10^{-2}.

iii. Mixing Concentrated Solutions and Handling Diluted Solutions

Treatment plant workers mixing concentrated (27%) inorganic arsenical formulations are exposed to arsenic through dermal contact with the concentrated solution and through inhalation of the background air arsenic levels in the plant. The Agency estimates that the combined inhalation and dermal dosage yields a lifetime oncogenic risk of 1.17×10^{-1} and a teratogenic/fetotoxic MOS of 135. The risk of skin cancer, which is primarily related to the dermal exposure, is estimated to be 9.8×10^{-2}. The risk of lung cancer to an individual, which is primarily related to the inhalation exposure, is estimated to be 1.9×10^{-2}.

The Agency has further determined that treatment plant applicators are also exposed when handling the diluted treatment solutions (1.7%). The estimated total risk of combined dermal and inhalation exposure from contact with diluted formulations, including background air arsenic level doses, yield a lifetime oncogenic risk of 2.6×10^{-2} and a teratogenic/fetotoxic MOS of 417. This oncogenic risk is composed of dermal and inhalation components. The risk of skin cancer to an individual, which is primarily related to dermal exposure, is estimated to be 7.0×10^{-3}. The risk of lung cancer to an individual, which is related to inhalation exposure, is estimated to be 1.9×10^{-2}.

iv. Opening Cylinder Doors

Because inorganic arsencial formulations are water-based solutions which do not typically produce vapors, the Agency has determined that the air arsenic concentrations while opening the cylinder door following treatment will not exceed the background air arsenic dust levels of the plant. However, while the cylinder door is being opened, it is possible to dermally contact the treatment solutions that have splashed and dried around the cylinder door. In addition, immediately after the door is opened, hooks are manually attached to the charge of wood for its removal from the cylinder. During this operation, the applicator dermally contacts the wet treatment solution. Due to a lack of data, the Agency has not estimated the combined dermal (diluted solution) and inhalation (background) exposure in this situation, but believes that there is some degree of risk.

v. Handling Treated Wood

Treatment plant workers handling treated wood while the wood is drying are exposed to the inorganic arsenical compounds via dermal contact (hand) with the liquid on the surface of the wood and through inhalation of the background arsenic-containing dust in the plant. The Agency recognizes that most wood stacking and handling is done mechanically with forklifts, especially in the larger, more automated plants. However, in smaller plants, manually handling treated wood is more common. The Agency has estimated that the total lifetime oncogenic risk to a treatment plant applicator involved in handling treated wood is 2.6 x 10^{-2}. This oncogenic risk is composed of dermal and inhalation components. The risk of skin cancer to an individual, which is primarily related to the dermal exposure, is estimated to be 7.0 x 10^{-3}. The risk of lung cancer to an individual, which is primarily related to inhalation exposure, is estimated to be 1.9 x 10^{-2}. The teratogenic/fetotoxic MOS for handling treated wood is estimated to be 417.

vi. Entering the Cylinders

While entering the cylinders for manual cleaning or for any other purpose (e.g., releasing a wood jam), the applicator may experience dermal exposure to the inorganic arsenical solution through contact with unprotected areas of the skin. Exposure also occurs through inhalation of background air arsenic levels and possibly through arsenic containing water vapors. Due to a lack of data, the Agency has not estimated the exposure to the treatment plant worker resulting from this activity but believes that there is some degree of risk.

c. Penta

The Agency has determined that penta or sodium penta poses a potential risk of fetotoxicity. Because technical penta and sodium penta are contaminated with hexachlorobenzene (HCB) and hexachlorodibenzo-p-dioxin (HxCDD), the use of penta or sodium penta also poses a potential risk of oncogenicity and teratogenicity*.

i. Background Air Levels of Penta or Sodium Penta

The data indicate that exposure to the background (ambient) air levels of penta or sodium penta and its contaminanants are not very great around a treatment plant. The Agency estimates that the oncogenic risk to an applicator involved in general activities around the plant is negligible ($<10^{-6}$) while the fetotoxic MOS is 730.

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* As the fetotoxicity NOEL (0.1 ug/kg/day) for HxCDD is lower than that for teratogenicity, the Agency used the NOEL for fetotoxicity in the quantitative assessment of risk to HxCDD (see Section II.D.5). In the case of technical penta, when the NOEL for the fetotoxicity of penta is considered in light of the exposure values, the margins of safety (MOS's) are lower than those obtained with the respective exposure values and NOEL for the fetotoxicity of HxCDD. Consequently, the MOS's for the fetotoxicity of penta are used in calculating the risk reduction for proposed modifications to the terms and conditions of registration.

ii. Bag Emptying

High inhalation and dermal exposure situations occur during the manual opening and emptying of bags of prilled (granular) or powder formulations of penta or sodium penta in the preparation of the treatment solutions. The data indicate that the total oncogenic risk is estimated to range from 7.3×10^{-3} to 1.5×10^{-2} during this operation, and the fetotoxic margins of safety range from 6.4 to 13.

iii. Mixing Concentrated Solutions and Handling Diluted Solutions

The Agency recognizes that the preparation of the working solutions of penta or sodium penta from concentrates is usually done automatically in mixing tanks or vats. Because the Agency does not expect exposure to penta or sodium penta to occur during this activity, discussion of this treatment plant process is not applicable.

iv. Opening Cylinder Door (Pressure Plants Only)

During the brief time (about 1 hour per day) an applicator may be opening cylinder doors following treatment, dermal and inhalation exposure to penta is expected to be significantly greater than during general activities around the plant. The Agency has data on the inhalation exposure but lacks information on the dermal exposure occuring during this activity. The oncogenic risk resulting from the inhalation component under these circumstances is estimated to be 6.4 x 10^{-4}; the MOS for fetotoxic effects is estimated to be 150 in this situation.

v. Handling Treated Wood

Dermal exposure to the workers in a treatment plant occurs during the handling of the wood that is still wet with the penta or sodium penta treatment solution. The Agency has not determined the exposure to an applicator involved in this activity due to a lack of data, but believes that there is some finite risk to the handlers of wood which has been freshly treated with penta or sodium penta.

vi. Entering Cylinders and Vats

While entering the treatment equipment for manual cleaning of the dirty cylinders in the pressure treatment plants (penta) and the vats containing the sodium penta or penta in non-pressure treatment plants, the applicator may experience dermal exposure to the treatment solution through contact with unprotected areas of the skin and through inhalation of vapors. Although the total exposure has not been quantified due to a lack of data, the Agency believes that there is some finite risk to the applicators during this activity.

vii. Dip and Spray Applications (Non-Pressure Plants Only)

To control the growth of sapstain mold on freshly cut wood, 0.5% sodium penta is used either as a dip or a spray. The spray treatment provides more inhalation exposure to applicators than does the dip treatment; this exposure occurs primarily via inhalation of aerosolized sodium penta solution. Dermal exposure to sodium penta is also expected to be high during both application processes. The fetotoxic MOS has been estimated to be 50 and 59 for spray and dip applicators, respectively. The total oncogenic risks are estimated to be 1.9×10^{-3} and 7.1×10^{-4} for spray and dip applicators, respectively.

Millwork and plywood are often dipped or sprayed with penta. The total penta exposure to an applicator at millwork dipping plants has been calculated to be 510 ug/kg/day, yielding an estimated fetotoxic MOS of 5.9 and a total oncogenic risk, due to exposure to HxCDD, of 7.1×10^{-3}.

At plants which spray penta on wood which will be used for millwork and plywood, the concentration of penta used is 2.5%. The Agency estimates an exposure to penta of 300 ug/kg/day. The fetotoxic MOS is estimated to be 10 and the total oncogenic risk is estimated to be 9.8×10^{-3}.

viii. Other Uses of Penta

The Agency has no data on the amount of penta to which an applicator in the particleboard treatment plant is exposed. Therefore, the risks resulting from this process cannot be quantified. However, the Agency believes that during several activities (e.g., bag emptying, handling treated particleboard, and entering treatment equipment for manual cleaning) there is potential exposure to penta and thus some finite risk to the applicator.

2. Summary of Benefits

The three wood preservatives, creosote, the inorganic arsenical compounds, and penta are usually the major substitutes for each other in the treatment of wood. While there are some minor alternatives including untreated wood (such as redwood and western red cedar), other wood preservatives (such as copper naphthenate) and structural alternatives (such as concrete and steel), these alternatives are all more expensive and/or in short supply, or, in the case of the alternative pesticides, have limited efficacy as wood preservatives. Consequently, if any one of the major wood preservatives were cancelled, it would be replaced by the remaining registered wood preservative pesticide(s) for the affected uses. However, severe economic impacts could result from this cancellation due to the necessary equipment changes that would be required to treat wood with the remaining registered wood preservatives. Moreover, the cancellation of certain uses, for which the remaining wood preservatives are not viable substitutes, would result in severe economic impacts.

Creosote application is preferred for the treatment of railroad ties which are more durable and lower in cost than other preservative-treated wood ties. Creosote and/or penta are preferred for timber which receives a high volume of heavy traffic because of the protection from weathering and abrasion that these preservatives impart to the wood. Creosote is preferred for marine use (pilings) because penta is not as efficacious and inorganic arsenical-treated pilings result in some breakage during shipping and mechanical driving. For lumber and plywood, inorganic arsenicals applications are preferred because the treated wood is clean, ordorless, paintable, easy to handle, harmless to plants and more durable when compared to either penta- or creosote-treated wood. Penta is the wood preservative agent of choice for posts, poles, and crossarms because penta-treated wood is cheaper in cost than creosote-treated wood and does not break or splinter as readily as does inorganic arsenical-treated wood.

If creosote were cancelled for all pressure treatment uses, the first year economic impact would range from $3.5 million to $25.8 million. For inorganic arsenicals, the first year impact of cancellation would be a cost increase ranging from $87.1 million to $87.6 million. Penta first year cancellation impacts would range from a $28.7 million to a $39.5 million cost increase. The annual long-term impacts would be an increase of $71.6 million for creosote, a cost increase from $79.8 million to $97.3 million for the inorganic arsenicals, and a decline in cost of $41 million to an increase of $48.1 million for penta (depending on which alternative is chosen).

The cancellation of penta or sodium penta for non-pressure applications (i.e., sapstain control, millwork and plywood, and particleboard uses) would generally result in the substitution of alternative wood preservatives at substantially higher cost to the applicator. Moreover, for most use patterns, the alternative pesticide chemicals do not provide the same efficacy as penta treatment.

A summary of the economic effects of cancelling one, two or all three of the wood preservatives on a use-by-use basis is given below. The areas of non-substitutability are emphasized.

a. Introduction

The Agency has evaluated the economic impact of the cancellation of one or more of the wood preservative agents in terms of the cost of substitution of the remaining registered wood preservative(s), or alternative materials, for the pressure and non-pressure treatment plant uses. This evaluation is based on information submitted by the registrants, material from the USDA-States-EPA Assessment Report and other information available to the Agency. The pressure treatment plant uses which were subjected to this benefits analysis include 1) railroad ties, 2) lumber, timber and plywood, 3) pilings, 4) posts, 5) crossarms, and 6) poles. The non-pressure treatment plant uses which were considered include 1) sapstain control, 2) millwork and plywood, and 3) particleboard.

All untreated wood products, regardless of their original strength, durability or natural resistance, are subject to degradation when placed in end-use situations which are conducive to attack by fungi, insects, bacteria or marine borers. The application of selected chemicals as wood preservatives protects wood from deterioration and frequently yields a product with significant advantages in terms of cost and performance over non-wood alternatives that might be available. The actual service life of treated wood products depends on the treated wood's inherent resistance to decay as well as on the environmental conditions of end-use, such as marine immersion or ground contact. An increase in life expectancy of five or more times that of untreated wood is achieved for most treated wood products.

b. Pressure Treament Plant Uses

i. Railroad Ties

In 1978, about 103.5 million cubic feet of railroad crossties and switchties were treated with wood preservatives for use in the railroad tie system in the United States. Approximately 99.6% of these ties were treated with creosote and the remaining

0.4% with penta. The high usage of creosote-treated ties reflects the greater strength and lower cost of the creosote-treated ties compared with other preservative-treated wood ties. Inorganic arsenical treatment is considered to be unacceptable for railroad tie use because inorganic arsenical-treated ties are brittle and do not hold fasteners well. Concrete ties are technically feasible substitutes for treated wood ties; however, treated wood ties and concrete ties cannot be intermixed in a given section since concrete ties settle more slowly than preservative-treated ties, resulting in an unstable track structure. Thus, the replacement of creosote-treated ties with concrete ties necessitates the replacement of all the ties in a given section of the railroad tie system.

The Agency has evaluated the economic benefits of preservative-treated wood railroad ties and has determined that there would be a major adverse economic impact of an average annual (annualized) cost increase of $40.5 million if creosote were cancelled and penta were still available (see Section III.B.4, Methods and Assumptions, for definition of annualized cost). The first year impact would result in a decline in cost of $18.2 million due to lower installation costs for penta-treated ties compared to creosote-treated ties. There would be little or no first year or ensuing long-term adverse economic impact if penta were cancelled and creosote were still available to the railroad industry. However, if both creosote and penta were cancelled, the most likely substitutes would be copper naphthenate-treated ties and concrete railroad ties. If copper naphthenate-treated or concrete ties are used, the average annual (annualized) costs for the railroad tie system would increase by $0.74 billion and $2.4 billion, respectively. The first year economic impacts would be an additional cost of $0.58 billion for copper naphthenate-treated ties and $3.7 billion for concrete ties. These projected adverse major impacts are based on the assumption that the supply of alternative materials is adequate for substitution at current prices.

ii. Lumber, Timber and Plywood

Treated lumber is used in a variety of end-uses formerly served almost exclusively by cedar and redwood. Shorter supplies and higher prices for the naturally resistant wood species have resulted in a great demand for treated wood. Inorganic arsenical-treated wood, which is suitable for almost all end-uses of lumber, timber and plywood, has been the primary replacement material for cedar and redwood.

An estimated 105.3 million cubic feet of lumber and timber were treated with the three wood preservatives in 1978. In addition, more than 2 million cubic feet of plywood and a substantial amount of sawn material were treated. In 1978, creosote was used for treating about 10.78 million cubic feet of lumber and timber. Industrial block flooring accounted for about 700,000 cubic feet of creosote-treated lumber; the other 10.08 million cubic feet of creosote-treated wood in this use category are used primarily as timbers for landscape, farm, mine and marine construction purposes. More than 70% of the total treated lumber and timber, about 73.32 million cubic feet, was treated with inorganic arsenicals and about 20%, or about 21.21 million cubic feet of lumber and timber, was treated with penta in 1978.

Based on efficacy and other performance characteristics, inorganic arsenical-treated wood is suitable for most end-uses of lumber, timber and plywood. Inorganic arsenical-treated wood is clean, odorless, paintable, easy to handle, harmless to plants and durable compared to either penta- or creosote-treated wood. Penta- and creosote-treated lumber, timber and plywood have limited uses due to odor, objectionable vapors, and oily, unpaintable surfaces. Inorganic arsenical wood preservatives are used for treating wood for such uses as patios, decks, playground equipment, cooling towers, greenhouses, horticultural nurseries and all weather wood foundations; these uses comprise the bulk of the market for treated lumber, timber, and plywood.

Creosote applications are preferred where treated wood is subject to a high volume of heavy traffic because of the protection from weathering and abrasion that it imparts to the wood. Penta in P9 oil also has these protective qualities (except for marine applications) and can be substituted for creosote for these uses; inorganic arsenicals are also an alternative for these use patterns except under conditions of high mechanical stress, due to the brittleness imparted by the inorganic arsenical treatment. Creosote-treated wood is also preferred for industrial applications in high acid environments due to creosote's high resistance to acids. Penta in heavy oil ranks second to creosote in this regard, with inorganic arsenicals having no acid resistance.

Since lumber, timber and plywood include a wide variety of treated wood used for many different end-uses, replacement costs could not be determined for all treated wood products in this use category. Thus, the total economic impact of cancellation of the three wood preservatives could not be estimated for comparison to the actual 1978 situation. If inorganic arsenicals were cancelled for lumber, timber and plywood, there would be major first year and major annual long-term adverse economic impacts since penta and creosote are not acceptable alternatives to the inorganic arsenicals for wood preservative treatment of lumber, timber and plywood.

If creosote were cancelled, there would be minor first year and minor annual long-term economic impacts of an additional cost of $39 million. If penta were cancelled, the first year estimated impact and subsequent annual impact would be an increase of $18 million. If penta and creosote were cancelled, the first year impact and the estimated annual long-term impact would be an increase of $5.2 million. It is clear that the economic impact resulting from cancellation of both creosote and penta is smaller than the impacts of cancellation of either creosote or penta alone. The inorganic arsenicals, which are less expensive than either of the other two preservatives, would be the major substitute if both creosote and penta were cancelled. However, 4.3 million cubic feet of transportation timbers that are currently treated with creosote would not be treated if both penta and creosote were cancelled.

If the inorganic arsenical compounds and penta were cancelled, there would be major first year and long-term cost impacts since creosote would not be an acceptable substitute for most uses of lumber, timber and plywood. If the inorganic arsenicals and creosote were cancelled, there would be major cost impacts since penta is not an acceptable substitute for most uses on lumber, timber, and plywood. If all three wood preservatives were cancelled, non-wood materials such as plastic, steel, or concrete would be substituted for the three wood preservatives. The economic impact resulting from this cancellation scenario cannot be determined because of the diversity of end-uses of lumber, timber, and plywood. However, it is expected that the non-wood materials would have a higher cost than treated wood and there may be important aesthetic impacts as well.

The Agency does have preliminary information on the impacts of the cancellation of inorganic arsenical-treated lumber used for home construction (e.g., all weather wood foundations, plates and sills, and structural framing). In a preliminary briefing given by the Mitre Corporation (EPA contract 68-01-5964, 1980), the impact of cancelling inorganic arsenical applications for treating lumber used in home construction was analyzed for the end-uses of all weather wood foundations (AWWF), plates and sills, and structural framing. There are about 10,000 homes built annually with AWWF (about 2,400 board feet of ACA- and/or CCA-treated lumber per home), about 750,000 homes with treated plates and sills (about 220 board feet of ACA- and CCA-treated lumber per home), and about 8,000 homes with treated structural framing (about 10,000 board feet of CCA-treated lumber per home). Most of the AWWF homes are located in the northern United States; homes which have treated plates and sills are found in the southern United States on slab foundations, and the structural framing homes are located only in Hawaii. In recent years, about 1% of the home foundations used treated wood or masonry and 99% used concrete. However, projections indicate an increasing market share for AWWF.

If inorganic arsenicals were cancelled for treating AWWF, the most likely substitutes would be concrete and masonry foundations. In rural, isolated areas in the northern United States, the use of AWWF results in a savings to the home buyer, but the concrete and masonry foundations are likely to be lower or equal in cost to those for AWWF in urban areas. Also, the possible benefits of AWWF in termiticide control are currently being reviewed by the Agency.

If the inorganic arsenicals were cancelled for treatment of plates and sills, the most likely substitute would be steel plates and sills. The use of steel plates and sills for home construction instead of treated wood would not result in a cost increase. If the inorganic asenicals were cancelled for the treatment of structural framing, the most likely substitutes would be concrete, masonry, and steel framing. The cost of these substitutes are similar to that of treated wood.

iii. Pilings

An estimated 12.09 million cubic feet of pilings were treated with wood preservatives in 1978 for use as marine and foundation pilings. Creosote was used to treat 82.7% of these pilings in 1978, while penta was the wood preservative for 9.5% of the pilings and the inorganic arsenicals were used for 7.8%. Penta is not recommended or used for marine pilings because it is not very efficacious; inorganic arsenicals could serve as an alternative for creosote in marine and foundation uses even though the brittleness imparted to pilings by inorganic arsenical results in some breakage of pilings during shipping and mechanical driving. Both concrete and steel can provide technically acceptable alternative materials for pilings in foundation uses.

The Agency has evaluated the economic benefits of treated wood pilings for the three wood preservatives and has determined that there would be a major adverse economic impact if penta or creosote were cancelled. The annual cost impacts would be a \$9-10 million increase for the cancellation of creosote and a \$8.3-9.0 million increase for the cancellation of penta. If the inorganic arsenicals were cancelled, the extent of the annual economic impacts would be minor since creosote-treated pilings could substitute for inorganic arsenical-treated pilings. If both penta and the inorganic arsenicals were cancelled for use on pilings, there would be a major annual cost increase of greater than $9.0 million*.

If both creosote and the inorganic arsenicals were cancelled, steel or concrete would be used as alternatives for 4.3 million cubic feet of marine pilings, since penta is not recommended or used for marine use. If penta and creosote were cancelled for pilings, the annual impact would be an additional cost of $8 million, for both the first and subsequent years. Under this scenario, the high cost increase for equipment changes is largely offset by the lower cost of inorganic arsenical-treated pilings.

If all three wood preservatives were cancelled, the most likely substitutes would be concrete for marine uses and concrete and steel for the foundation uses. However, steel would be subject to corrosion in highly acidic soils or in marine environments. The costs of both concrete and steel pilings (including installation costs) are higher than treated wood piles on a one for one basis. If concrete or steel pilings are used instead of treated wood pilings, the total average annual (annualized) installed cost (see Section III.B.4, Methods and Assumptions, for definition) of pilings would increase by 33.3% ($64.5 million) for concrete and 67% ($129.1 million) for steel compared to the 1978 annualized cost of treated wood pilings (assuming a one to one replacement for the wood pilings). However, if concrete and steel piles are assigned heavier loads than those previously assigned to treated wood piles, the total average annual installed cost of pilings could decrease by as much as 11% for concrete and increase by as much as 11% for steel, compared to the 1978 annualized cost of treated wood pilings. In the use of foundation pilings in residential and small commercial buildings where loads are relatively low, concrete or steel pilings will usually be much higher in cost than treated wood pilings.

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* The cancellation of both penta and the inorganic arsenicals results in an impact similar to that of cancelling penta or the inorganic arsenicals singly due to the high usage of creosote-treated ties.

iv. Posts

In 1978, an estimated 20 million cubic feet of posts were treated with preservatives. Treated wood posts include such uses as fences, highway guardrails and signposts; farm fence posts account for the largest proportion of treated posts used. The average service life of untreated fence posts is only 3.3 years, compared with 38 years for creosote- or inorganic arsenical-treated posts (ACA) and 33 years for posts treated with penta. The 1978 distribution of fence posts by treatment chemical was 22.9% for creosote, 54.8% for penta and 22.3% for the inorganic arsenicals. The total cost of treated wood posts in 1978 was $66.1 million.

The Agency has evaluated the benefits of the three wood preservatives for posts and has determined the economic impacts if one or more of the three wood preservatives were cancelled. If penta were cancelled, there would be a moderate economic impact, an annual cost increase for the first and subsequent years of $0.75 million to $5.1 million in treated wood posts, depending on which alternative (e.g., creosote or inorganic arsenicals) is chosen. If creosote were cancelled, there would be a moderate economic impact of a $3.3 million annual cost increase for the first and subsequent years. If the inorganic arsenicals were cancelled, the first year and annual long-term impacts would be a cost increase of $4.0 million to $4.5 million in treated wood posts depending on which alternative (e.g., creosote or penta) is chosen; this impact is viewed as moderate.

If both creosote and the inorganic arsenicals were cancelled, there would be major adverse economic impacts for both the first year and subsequent years; the economic impact is estimated to be an annual cost increase of greater than $7 million for treated wood fence posts. If both inorganic arsenicals and penta were cancelled, there would be a moderate adverse economic impact for both the first and subsequent years (an annual increase in post cost of greater than $5.1 million). Under this cancellation scenario, steel posts would probably replace treated wood posts for suburban uses since creosote-treated posts are unacceptable replacements. However, if both creosote and penta were cancelled, there would be minor adverse first year and annual long-term impacts; this impact is estimated, based on current levels of usage, to be an annual cost increase of $383,000.

If all three wood preservatives were cancelled, steel or concrete posts would be the most likely alternative materials that would be used for fence posts. T-type steel posts, which serve as substitutes for treated wood posts in farm uses, are priced competitively with treated wood posts. Thus, substitution of steel posts in many farm uses would not necessarily lead to higher fencing cost. Concrete posts would be more expensive than steel and probably would not be substituted in most farm situations.

v. Crossarms

Crossarms are the cross members of assembled utility poles. An estimated 1,685,000 cubic feet of crossarms were treated with wood preservatives in 1978. The distribution of crossarms by preservative treatments was 2.5% for creosote, 95.8% for penta and 1.7% for the inorganic arsenicals. The 1978 cost of treated crossarms was estimated as $14.86 million. The service lives of crossarms treated with the three major wood preservatives are considered to be equivalent (40 years). Steel crossarms can be used as alternatives for treated wood crossarms in some use situations.

The Agency has evaluated the benefits of the three wood preservatives for crossarms and has determined the economic impacts if one, two, or all three wood preservatives were cancelled. If penta were cancelled for the crossarm use, there would be minor to moderate adverse economic impacts for both the first and subsequent years ranging from a decline in annual cost of $0.23 million to an additional annual cost of $1.2 million, depending upon which alternative (i.e., creosote or inorganic arsenicals) is chosen. If creosote were cancelled, there would be minor adverse first year and annual long-term impacts, ranging from a decline in cost of $15,000 to $30,000, depending on which alternative (i.e., inorganic arsenicals or penta) is chosen. These economic impacts are based on current preservative prices and do not include any additional investment costs for conversion from one treatment process to another. If the inorganic arsenicals were cancelled, there would be a slight increase in treated crossarm cost, resulting in minor adverse first year and annual long-term impacts.

If both the inorganic arsenicals and penta were cancelled, there would be an additional annual cost of $1.2 million for treated crossarms, which represents a moderate adverse economic impact. If both the inorganic arsenicals and creosote were cancelled for the crossarm use, there would be an annual decline in cost of $0.2 million. If both penta and creosote were cancelled, there would be a small decline in the annual cost of treated crossarms.

If all three wood preservatives were cancelled, the most likely substitute would be steel crossarms. The steel crossarms would be competitive with treated crossarms for some uses, but, in most instances, this cancellation scenario would result in higher crossarm costs and a major adverse economic impact.

vi. Poles

Treated poles are the principal structural support elements in the 4.52 million miles of the electric distribution system and the estimated 640,000 miles of electrical transmission lines in the United States. Treated poles are also used to support telephone lines, as light standards, and for construction uses in residential and other buildings. In 1978, an estimated 64.2 million cubic feet of wood were treated for pole uses (representing 2.86 million treated poles). The distribution of the three preservatives for pole treatment by volume in 1978 was 65.3% for penta, 28.4% for creosote and 6.3% for the inorganic arsenicals. There are no viable chemical alternatives for the three major wood preservative agents for pole treatment with the possible exception of copper naphthenate for certain limited uses. However, copper naphthenate is unsuitable for large-scale use on poles because it imparts a green, greasy surface to the poles, is unstable in the presence of moisture and causes corrosion of metals. Non-wood alternatives for treated poles include the use of concrete and steel as pole construction materials, and the installation of underground distribution and transmission lines in urban areas or in new subdivisions.

The Agency has evaluated the benefits of the three major wood preservatives for poles and has determined the economic impact on the distribution and transmission pole system if one, two, or all of the three wood preservatives were cancelled. If penta were cancelled for poles, there would be a first year cost increase ranging from $19.9 million to $24.2 million depending upon which alternative is chosen (i.e., creosote or inorganic arsenicals). The long-term economic impact for the cancellation of penta would range from a total annualized cost (see Section III.B.4, Methods and Assumptions, for definition) decrease of $43.6 million* to an average annual cost increase of $32.8 million. If creosote were cancelled there would be a major adverse economic impact for the first year with an additional cost of $9.4 million to $20.7 million. The long-term impact would range from an average annual decline in cost of $43.6 million to an additional cost of $17.8 million and could cause a major adverse economic impact. If inorganic arsenicals were cancelled, there would be a minor adverse impact of an additional cost of $1.9 million for the first year and a major adverse economic impact (additional average annual cost of $17.8 million to $32.8 million) for each subsequent year.If penta and creosote were cancelled, there would be an additional first year cost of $28 million and an average annual decline in cost of $43.6 million in subsequent years. If penta and the inorganic arsenicals were cancelled, there would be major adverse economic impact with a cost increase of $35.5 million in the first year and an average annual cost increase of $32.8 million in subsequent years. The cancellation of creosote and the inorganic arsenicals would result in an additional first year cost of $24.3 million and an average annual cost increase of $17.8 million in subsequent years, or major economic impacts. If all three major wood preservatives were cancelled for poles, the most likely substitutes would be concrete and steel. Under this cancellation scenario there would be a large first year cost increases and major adverse impacts in subsequent years ranging from $1.3 billion to $2.06 billion (average annual cost) depending upon the alternative which is chosen.

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* Even though there is a decline in the average annual cost of $43.6 million for the treated poles (users' savings), the first year impact to the applicators for conversion is major (an increase of about $9.4-28.0 million).

c. Non-pressure Treatment Plant Uses

i. Sapstain Control

Although the most serious structural damage to wood is caused by insects and decay, sapstain fungi infestion increases the capacity of the wood to absorb moisture thus making the wood more vulnerable to decay. Sapstain fungi infestation also causes discoloration which reduces the market value of the wood. Currently, sodium penta is the primary antimicrobial used to control sapstaining and surface staining fungi in the United States. About 1.15 million pounds of sodium penta are used annually for this purpose. The sodium penta solutions often include the salts of other chlorinated phenols.

The alkali salts of tetrachlorophenol (tetra) have been used effectively for sapstain control for over 40 years; in recent years, however, sodium penta has replaced sodium tetra as the primary antimicrobial for sapstain control. Copper-8-quinolinolate (Cu-8) is currently registered for sapstain control; information is unavailable on the volume of Cu-8 used for sapstain control and the effectiveness of this chemical for this use. Kiln drying can be used to prevent sapstain for most softwoods; however, kiln drying cannot be utilized in those situations where freshly-cut lumber cannot be placed in the kiln within 48 hours. Kiln drying is also not appropriate for a number of hardwood species which are subject to warping and honeycombing during kiln drying.

The Agency has evaluated the benefits of sapstain control and has determined that there would be a minor adverse economic impact if sodium penta were cancelled. The most likely substitutes for controlling sapstain would be the alkali salts of tetrachlorophenol (e.g., sodium tetra) which are equal in cost and efficacy to sodium penta. There would be only minor changes in treatment cost if applicators switched from sodium penta to sodium tetra for sapstain control; no adverse economic impacts in consumer prices for lumber are anticipated if sodium tetra replaces sodium penta for this use. Other alternatives (e.g., Cu-8 and a formulation of Cu-8 and potassium tetra) are available at a slightly increased cost; these alternatives, however, may not provide adequate protection for sapstain control.

ii. Millwork and Plywood

Millwork includes wood windows, sash screens, blinds, shutters, window frames, doors, doorframes and mouldings, as well as machined parts of these products. All of these items are manufactured primarily from ponderosa pine and other softwoods which have a low natural resistance to decay. Millwork and softwood plywood are usually treated with a 5% penta solution in mineral spirits (containing water repellants) which is applied by spraying, brushing, dipping or by the vacuum process. Available alternatives include tributyltin oxide (TBTO), Cu-8, and non-wood structural materials such as aluminum. Penta is colorless, compatible with paints, stains, sealers and primers, and does not interfere with the adhesion of glazing compounds, caulkings or other sealants. The 0.75% TBTO formulations are effective for exterior millwork which is painted, varnished or coated subsequent to TBTO treatment; however, when the TBTO-treated wood is subjected to severe exposure, the prolonged service life provided by 0.75% TBTO will not equal that of penta. The 0.25%-0.3% Cu-8 solutions are approved by the National Wood Manufacturers Association (NWMA) for use on millwork, but not recommended by the National Forest Products Association for millwork protection. A water-based Cu-8 product (0.5%) is available, but has not been approved for use by the NWMA.

The Agency has evaluated the benefits of millwork and plywood and has determined that there would be a minor adverse economic impact to the millwork and plywood industry if penta were cancelled. The most likely alternatives for penta would be TBTO, Cu-8 or nonwood structural materials (e.g., aluminum).

If penta is cancelled, millwork and plywood manufacturers would likely switch to TBTO, which costs about the same as penta and is effective for above ground exposure if the TBTO-treated wood is painted. If the water-based Cu-8 solution proves to be efficacious, many penta users would switch to this formulation.

Other alternatives that could be substituted for penta would be untreated wood, which would require frequent replacements and would increase the demand for wood products, naturally resistant wood, and non-wood materials (e.g., aluminum).

iii. Particleboard

In some areas of the United States it may be necessary to treat particleboard to prevent attack by dry-wood termites and other wood destroying insects. Penta is presently the only effective preservative used for this specific purpose. There is currently only one known plant in the United States producing penta-treated particleboard. The penta-treated particleboard constitutes less than 1% (about 170,000 square feet) of the average annual particleboard production at the plant and represents a very small part (about 0.005%) of the 3.9 billion square feet of particleboard produced in the United States in 1978. The production of treated particleboard generates an annual revenue of about $35,000. Thus, even though there are no registered alternatives for the particleboard used, the economic impacts would be minor if penta were cancelled for this use.

3. Risk/Benefit Analysis

a. Consideration of Regulatory Options

The Agency has determined, based on the evaluation of risk and benefit information, that the treatment plant application of wood with creosote, the inorganic arsenical compounds, and penta poses unreasonable adverse effects to treatment plant workers. Therefore, the registration of these wood preservatives cannot be simply continued for these uses, i.e., railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, sapstain control, millwork and plywood, and particleboard. Cancellation is, however, not a desirable option because the economic benefits of the wood preservatives are very large, and severe economic impacts could result if one or more of the three wood preservatives were cancelled. Moreover, the risks of other chemical preservatives are unknown, the substitutability of chemical alternatives is questionable, and the uncertainty levels surrounding the risks are large. Before considering cancellation for one or more of the preservatives on one or more use sites, the Agency will consider Option 2, the Modification of the Terms and Conditions of Registration, to determine if risk reduction measures can reduce the risk to acceptable levels. In the following sections, the Agency will evaluate the impacts of the modifications under consideration on risk reduction and on the benefits of use. The Agency examined all risk reduction options which could reduce exposure without causing major economic impacts. For those situations where the risk cannot be reduced to acceptable levels the Agency will select Option 3, Cancellation.

b. Risk/Benefit Impacts of Modifications Under Consideration for Treatment Plants

i. Gloves

The Agency does not have sufficient data that would allow a quantitative determination of dermal exposure to workers opening pressure cylinder doors. It is clear, however, that residues of the preservative solution may accumulate on the surface of the doors. The Agency believes that dermal exposure during this activity will occur almost entirely via the hands.

During the manual empyting of bags of prilled or powder formulations of penta or sodium penta, or inorganic arsenical powders, dermal exposure can occur through other parts of the body besides the hands. However, the Agency estimates that during this activity, exposure to the hands is significant. It has also been shown that a potential exists for hand dermal contact to occur while the inorganic arsenical solutions are being prepared and mixed for use in the treatment process.

Contact with wood which has been freshly treated with any of the three wood preservatives provides ample opportunity for hand dermal exposure, as does the entering of the treatment cylinders (all three preservatives) and vats (penta or sodium penta) for any purpose (e.g., manual cleaning). With regard to the spray and dip operations in the non-pressure treatment of wood with penta or sodium penta, the Agency has determined that hand dermal exposure is likely.

To reduce hand dermal exposure to the three wood preservatives in the treatment plants, the Agency will consider requiring all wood treatment applicators to wear gloves (e.g., rubber) impervious to the wood treatment solution when coming into hand contact with these pesticides. Wearing gloves is estimated to reduce hand dermal exposure by 99% (Kozak, 1980).

Due to insufficient data, the Agency has been unable to quantify the hand dermal exposure resulting from activities in which contact with the creosote solution is likely to occur (see Section V.B.1.a). However, an applicator wearing gloves resistant to penetration by creosote solutions would have a significantly reduced (by 99%) exposure to creosote via the hands.

Due to insufficient data, the Agency has been unable to quantify the hand dermal exposure resulting from entering cylinders and opening cylinder doors in which contact with the inorganic arsenical solution is likely to occur (see Section V.B.1.b).

However, an applicator wearing gloves (e.g., rubber) resistant to penetration by the inorganic arsenicals would have a significantly reduced (by 99%) exposure to inorganic arsenicals via the hands.

Wearing gloves reduces the total dermal inorganic arsenical exposure from 17 ug/kg/day to 0.17 ug/kg/day while handling treated wood and diluted solutions. The total lifetime oncogenic risk from exposure to the diluted inorganic arsenical solution or handling treated wood is reduced from 2.6×10^{-2} to 1.91×10^{-2} and the teratogenic/fetotoxic MOS is increased from 417 to 499. The risk of skin cancer to an individual, which is primarily related to dermal exposure, may be reduced from 7.0×10^{-3} to 1.0×10^{-4} by wearing gloves.

By wearing gloves, the total oncogenic risk from mixing the inorganic arsenical concentrates is reduced from 1.17×10^{-1} to 2.0×10^{-2} and the teratogenic/fetotoxic MOS is increased from 135 to 487. The risk of skin cancer to an individual, which is primarily related to dermal exposure, may be reduced from 9.8×10^{-2} to 1.3×10^{-3}.

The total dermal exposure is reduced from 1.6 ug/kg/day to 1.12 ug/kg/day when gloves are worn while emptying bags (or other containers) of inorganic arsenical powder formulations. Gloves are not especially effective in reducing risks from emptying bags of powder formulations since hand exposure only accounts for 30% of the total dermal exposure. The total lifetime oncogenic risk from bag emptying is reduced from 3.4×10^{-2} to 3.2×10^{-2} and the teratogenic/fetotoxic MOS is increased from 294 to 310. The risk of skin cancer to an individual, which is related to dermal exposure, may be reduced from 6.0×10^{-3} to 4.4×10^{-3}.

Although the Agency has not quantified the hand dermal exposure to penta or sodium penta for entering cylinders and vats, opening the cylinder door, and handling treated wood because of a lack of data, an applicator wearing gloves resistant to penetration by penta or sodium penta solutions would have a significantly reduced (by 99%) exposure to penta or sodium penta via the hands.

Wearing gloves during the emptying of bags (or other containers) of prilled penta or sodium penta reduces the total dermal exposure from a range of 27 to 270 ug/kg/day to 19 to 190 ug/kg/day. Gloves are not especially effective in reducing risks from emptying bags of prilled (granular) formulations. The total lifetime oncogenic risk from exposure to penta or sodium penta during this activity is reduced from a range of 7.3×10^{-3} to 1.5×10^{-2} to a range of 7.1×10^{-3} to 1.3×10^{-2} and the fetotoxic MOS is increased from a range of 6.4 to 13 to a range of 7.7 to 14.

Wearing gloves during the spraying or dipping applications of penta (non-pressure) reduces the total dermal exposure from 500 to 5.0 ug/kg/day (dip) and from 250 to 2.5 ug/kg/day (spray).

The corresponding fetotoxic MOS, after addition of the inhalation exposure, is increased from 5.9 to 210 for dip operations and from 10 to 57 for spray operations. Dermal exposure to HxCDD is also reduced by 99%. The total oncogenic risks are thus reduced from 7.1×10^{-3} to 7.1×10^{-5} for dip operations and from 9.8×10^{-3} to 1.7×10^{-3} for spray operations.

Wearing gloves during the spraying and dipping applications of sodium penta (non-pressure) reduces total dermal exposure from 50 to 0.5 ug/kg/day. The fetotoxic MOS, after addition of inhalation exposure, is increased from 59 to 6,000 for dip operations, and from 50 to 290 for spray operations. The corresponding oncogenic risks due to exposure to HxCDD are reduced from 7.1×10^{-4} to 7.1×10^{-6} for dip operations and from 1.9×10^{-3} to 3.4×10^{-4} for spray operations.

For the wood preserving industry which uses pressure treatment, the cost of requiring gloves ranges from $210,000 to $1,100,000 per year (assumes some protective clothing is currently available to the applicators), or about $3,500-18,000 for large plants and about $900-4,700 for small plants, depending on the number of workers in the plant (Mitre, 1980). For the wood preserving industry which uses non-pressure treatment to preserve wood, the implementation of this modification (assuming that some protective clothing is already provided to the applicators) would cost as follows: for sapstain control, $300 to $1,560 annually per plant with a total cost to the sawmill industry of $630,000; for millwork and plywood, $300 to $1,560 annually per plant with a total cost to the millwork and plywood industries of $630,000; and for the one plant involved in producing penta-treated particleboard, the cost would range from $60 to $312 per worker (Mitre, 1980; EPA, 1980).

ii. Disposable Coveralls and Gloves

Most arsenical wood treatment formulations are shipped to the plants as liquids. However, the smaller, less modern plants still regularly use and mix powder formulations at the plant several times a week, thus creating a potential for dermal exposure through the body, arms, and neck, as well as the hands. During the manual emptying of bags of prilled or powder formulations of penta or sodium penta, there is also dermal exposure via routes other than the hands, such as the body, arms and neck of the applicator.

To reduce this total dermal exposure (hands, body, arms, and neck), the Agency will consider requiring applicators who empty bags and other containers and mix powder formulations of the inorganic arsenical compounds or bags of prilled or powder formulations of penta or sodium penta to wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing and gloves (e.g., rubber) where closed emptying and mixing systems are not used. This modification will reduce total dermal exposure by 80% (Kozak, 1980). However, the Agency estimates that during this activity, exposure to the hands accounts for about 30% of the total dermal exposure.

Wearing disposable coveralls and gloves during the bag emptying and mixing of powder formulations of the inorganic arsenicals reduces the total dermal exposure from 1.6 to 0.32 ug/kg/day. The ability of gloves and coveralls to reduce risk is limited, since the inhalation component of exposure is significant. The total lifetime oncogenic risk from exposure to the inorganic arsenicals during this activity is reduced from 3.4×10^{-2} to 3.0×10^{-2} and the teratogenic/fetotoxic MOS is increased from 294 to 326. The risk of skin cancer to an individual, which is primarily related to dermal exposure, may be reduced from 6.0×10^{-3} to 2.0×10^{-3}.

Wearing disposable coveralls and gloves during the emptying of bags of prilled penta or sodium penta reduces the total dermal exposure from a range of 27 to 270 ug/kg/day to a range of 5.4 to 54 ug/kg/day. The total lifetime oncogenic risk from exposure to penta or sodium penta during this activity is reduced from a range of 7.3×10^{-3} to 1.5×10^{-2} to a range of 6.6×10^{-3} to 8.2×10^{-3}, and the fetotoxic MOS is increased from a range of 6.4 to 13 to a range of 12 to 15.

The annual cost to the pressure and non-pressure wood preserving industries for disposable coveralls and gloves ranges from $20 to $40 per worker ($80 to $160 per plant) for coveralls and $60 to $312 per worker ($240 to $1,248 per plant) for rubberized gloves. The combined cost (gloves and disposable coveralls) of implementing this modification ranges from $320 to $1,400 per plant annually (Mitre, 1980; EPA, 1980).

iii. Neoprene-Coated Cotton or Rubberized Overall, Jacket, Gloves and Boots, and a Respirator

There are occasions when it is necessary for a treatment plant applicator to enter a pressure cylinder (e.g., for manual cleaning or releasing a wood jam). During such an activity, there is clearly a great opportunity for both dermal and inhalation exposure. This potential for high exposure to the treatment solution exists in all pressure treatment plants, whether creosote, inorganic arsenicals, or penta is the preservative being used. A similar potential for high exposure exists during the cleaning of non-pressure treatment equipment (e.g., vats for penta or sodium penta).

As with creosote and penta, the risks resulting from exposure to the inorganic arsenicals have not been quantified for applicators entering cylinders due to insufficient data. However, based on the evaluation of total oncogenic risks resulting from background air arsenic levels in the plant (1.9×10^{-2}) and risks from contacting diluted (2.6×10^{-2}) and concentrated (1.17×10^{-1}) treatment solutions, the Agency has determined that risks to personnel entering the cylinders for manual cleaning the insides of arsenical treatment cylinders or performing other activities inside the cylinder (e.g., releasing treated wood jams) would be greater than the risks from the background inhalation exposure and the dermal exposure from mixing concentrates and handling the diluted solutions.

To reduce these risks, the Agency will consider requiring applicators who enter pressure treatment cylinders or vats (non-pressure) to wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use. A respirator will also be considered for applicators who are opening cylinder doors for penta and creosote* and during the spraying operations of penta or sodium penta (non-pressure treatments). Only a few workers (about four per plant) are involved in these activities and this type of cleaning is usually done only once or twice a year (Mitre, 1980).

A cartridge respirator will reduce inhalation exposure to these wood preservatives by about 90% (Kozak, 1980). The use of a neoprene-coated cotton or rubberized overall, jacket, gloves and boots will reduce total dermal exposure by about 80% (Kozak, 1980).

Due to insufficient data, the Agency has not quantified the total exposure to either the pressure or the non-pressure treatment plant applicator who is involved in these activities (e.g., entering the cylinders or vats, or opening cylinder doors following treatment). However, the Agency believes that an applicator wearing this protective clothing and a respirator while perfoming these activities will have a significantly reduced inhalation (by 90%) and dermal exposure (by 80%), resulting in significantly reduced risks.

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* The Agency believes that the air concentrations of arsenic while opening the cylinder door will not exceed the background air arsenic dust levels of the plant. The Agency is considering another modification (i.e., dust mask) in order to reduce this background (ambient) arsenic exposure (see Section V.B.3.b.iv).

Wearing a respirator during the non-pressure spray operations of penta reduces the total estimated lifetime oncogenic risk from 9.8×10^{-3} to 8.3×10^{-3}, and increases the fetotoxic MOS from 10 to 12. Wearing a respirator while spraying sodium penta for sapstain control reduces the total estimated lifetime oncogenic risk from 1.9×10^{-3} to 1.6×10^{-3}; the fetotoxic MOS is increased from 50 to 590. Although the reduction in risk with respirators does not appear to be particularly great, the Agency believes that, at least during the actual spraying process, there is a potential for significant applicator exposure to airborne droplets or mist containing the preservative if a respirator is not worn.

For the wood preserving industry which uses pressure treatment, the cost of this protective clothing and respirators ranges from \$368,000 to \$446,000 per year, or about \$2,194 to \$3,474 per plant annually. The cost depends on the number of workers in the plant and assumes that some protective clothing is already provide to employees (Mitre, 1980).

For the wood preserving industry which uses non-pressure treatment to preserve wood, the implementation of this modification would cost as follows: for sapstain control, \$2,194 to \$3,475 annually, per plant, with a total cost to the sawmill industry of \$2.56 million to \$4.16 million; for millwork and plywood, \$2,194 to \$3,474 annually, per plant, with a total cost to the millwork and plywood industries of \$2.56 million to \$4.16 million; and for the one plant involved in producing penta-treated particleboard, the cost would range from \$2,194 to \$3,474, (Mitre, 1980; EPA, 1980). These cost estimates assume that some of these protective clothing and equipment are currently supplied to the applicators by the plant.

iv. Dust Masks

The manual opening and emptying of bags (or other containers) of prilled or powder formulations of penta or sodium penta, or powder formulations of the inorganic arsenicals are activities where inhalation exposure has been shown to be high (see Sections V.B.1.b.ii and V.B.1.c.ii). The ambient air of plants treating with the inorganic arsenical compounds contains microscopic particles of arsenic. The arsenic dust is evenly distributed throughout the plant, rather than being localized, and poses an oncogenic risk of 1.9×10^{-2} to all treatment workers breathing this ambient air.

To reduce this inhalation exposure, the Agency will consider requiring applicators and personnel (see discussion under Section V.B.1 for definition of applicator) working outdoors in arsenical wood treatment plants to wear a disposable dust mask which traps 80% of 5-micron or greater particulates. This dust mask will also be considered for applicators who empty bags of prilled or powder formulations of penta or sodium penta, or powder formulations of inorganic arsenicals, or who mix these powder or prilled formulations where closed emptying and closed mixing systems are not used.

Wearing a dust mask while working outdoors in an arsenical wood treatment plant reduces the total inhalation exposure from 10 to 2 ug/kg/day. The total lifetime oncogenic risk from exposure to the inorganic arsenicals during this activity is reduced from 1.9×10^{-2} to 3.8×10^{-3}, and the teratogenic/fetotoxic MOS is increased from 500 to 2,500.

Wearing a dust mask during the emptying of bags of inorganic arsenical powder formulations reduces the total exposure from 17.0 to 4.6 ug/kg/day. The total lifetime oncogenic risk from exposure to the inorganic arsenicals during this activity is reduced from 3.4×10^{-2} to 1.17×10^{-2}, and the teratogenic/fetotoxic MOS is increased from 294 to greater than 1,000. The risk of lung cancer, which is primarily related to inhalation exposure, is reduced from 2.8×10^{-2} to 5.7×10^{-3}.

Wearing a dust mask during the emptying of bags of prilled or powder penta or sodium penta formulations reduces the lifetime oncogenic risk due to HxCDD exposure from a range of 7.3×10^{-3} to 1.5×10^{-2} to a range of 1.7×10^{-3} to

7.8×10^{-3}. The fetotoxic MOS is increased from a range of 6.4 to 13 to a range of 8.9 to 57.

For the wood preserving industry which uses pressure treatment, the cost of a dust mask for an applicator would cost about $120 per year, or about $1,200 to $6,000 per plant annually, depending on the number workers in the plant. The total cost to the wood preserving industry ranges from $1.08 million to $1.56 million annually. This cost estimate assumes that the plants do not provide dust masks to its employees.

For the wood preserving industry which uses non-pressure treatment to preserve wood, the implementation of this modification would cost as follows: for sapstain control, $1,200 annually per plant with a total cost to the sawmill industry of $2.4 million for millwork and plywood, $360 to $600 annually per plant with a total cost to the millwork and plywood industries of $0.72 million to $1.2 million; and for the one plant involved in producing penta-treated particleboard, the cost for dust masks would be $1,200 annually. These cost estimates assume that the plants do not provide employees with the protective clothing.

v. Require Proper Disposal of Protective Clothing

Although not quantified, there are potential risks from creosote, the inorganic arsenicals and penta containing dust or solutions which stick to protective clothing and work shoes, and are transported from the treatment plant into the home. This creates a potential exposure to the workers' families.

To eliminate this potential source of exposure, the Agency will consider the requirement that wood treatment plant workers leave all protective clothing and work shoes or boots, at the plant at the end of the day. This modification will also require that worn-out protective clothing be disposed of in accordance with the instructions for the pesticide container disposal.

The economic impacts to the wood treating industry are minor for leaving protective clothing at the plant. Currently, 75% of protective clothing is left at treatment plants (Mitre, 1980). The cost for this modification entails the purchase price of one or two pairs of work shoes or boots per year. This cost ranges from \$30 to \$80. For the pressure treatment industry, the cost would range from \$1,900-5,000 for large plants and \$570-1,500 for small plants (Mitre, 1980)

The cost for work shoes or boots to the non-pressure treatment industry are: \$300 to \$800 per plant annually (sapstain control); \$150 to \$400 per plant annually for millwork and plywood; and \$300 to \$800 for the one plant that treats particleboard with penta.

vi. Prohibit Eating, Drinking, and Smoking During Application

It is not unusual for plant workers to eat their lunches and smoke in the yard around stacks of treated wood thus creating a potential for accidental ingestion through contamination of food and drinks and inhalation by smoking. Although the risks of accidental contamination with wood preservatives through eating, drinking and smoking have not been quantified, the Agency believes there is a potential risk from these activities.

To achieve a reduction in these risks, the Agency will consider the prohibition of eating, drinking and smoking by applicators during the application of the wood preservatives or in the immediate vicinity of application. In the implementation of this modification, the Agency would require that wood treatment plants provide designated areas for eating, drinking and smoking.

The costs of implementing this modification have not been quantified, but they are not expected to be large.

vii. Confine Emptying and Mixing Operations to Closed Systems (Powder and Prilled Formulations)

In a number of small wood treatment plants, the applicators open bags (or other containers) and empty by hand prilled or powder formulations of penta or sodium penta, or powder formulations of the inorganic arsenical compounds into the dissolving tanks (creosote is not formulated as a powder). This open system of transferring and mixing these formulations with solvents poses an extremely high degree of dermal and inhalation exposure to the applicator. As discussed previously in this section, gloves and coveralls have limited effectiveness in reducing the dermal exposure; a dust mask provides some reduction in inhalation exposure.

To reduce this exposure, the Agency will consider requiring closed systems for the emptying and mixing of powder formulations of the inorganic arsenicals, and prilled or powder formulations of penta and sodium penta. An example of an acceptable closed emptying and mixing system is one in which powder or prilled formulations are unloaded by pneumatic equipment from a hopper truck or railroad car directly into the closed dissolving (mixing) tanks.

Implementation of this modification is expected to reduce the applicator exposure to penta, sodium penta, and the inorganic arsenicals to a level that is comparable to the background (ambient) air levels in the plant.

Although the exact number of treatment plants which manually empty or mix prilled and powder formulations of penta and sodium penta, or the inorganic arsenical powder formulations is not known, the Agency estimates that the cost of installing these closed systems would be about $10,000 to $12,000 per plant.

viii. Classify for Restricted Use

The Agency believes that education and training regarding pesticide application would increase the care with which the wood preservatives are handled and applied, thereby lowering exposure to these wood preservative chemicals by some finite amount. Therefore, the Agency will consider classifing the wood preservatives as restricted use pesticides. Classifying the wood preservatives for restricted use would require a minimum of one certified applicator per plant. This modification has the potential to reduce exposure as a result of educational measures, especially in the small treatment plants where applicators have little or no guidance. The Agency recognizes that there would probably be only a small impact on exposure to applicators in the larger automated plants.

The total cost of implementing this modification to the pressure treatment industry ranges from $12,000 to $24,500 or about $25 to $50 per plant. The costs to the non-pressure treatment industry is $36,000 to $72,000 each for the sapstain, and millwork and plywood industries, and $25 to $50 for the one plant treating particleboard with penta.

ix. Reduce Arsenic Surface Residues on Treated Wood

Workers in treatment plants that apply inorganic arsenical formulations are subject to oncogenic, teratogenic and mutagenic risks via inhalation of background (ambient) arsenic dust. This dust results from the leaching, drying, and subsequent flaking off of the inorganic arsenical formulations from the surface of the treated wood which is drying in the yards. Treatment plant applicators are also exposed to residues of arsenic via handling of dry treated wood.

To reduce this source of inhalation and dermal exposure to the treatment plant applicator, the Agency will consider requiring the applicators to filter the treatment solutions prior to use in the treatment cylinders and to include an additional vacuum step prior to the removal of the treated wood from the treatment cylinders. In addition to these requirements, the Agency will consider recommending the use of wood that is free of heavy resins ("clean" wood), the post-treatment rinsing of the treated wood, and the installation of protective sheds or covers over the drying treated wood.

Reducing surface residues of arsenic on the treated wood is expected to reduce the inhalation and dermal exposure to an applicator; and additional risk reductions would also be achieved by reducing the dermal and inhalation exposure to the end-users of the treated wood. End-users of the treated wood include children coming into contact with arsenically treated playground equipment and workers handling arsenically treated wood and breathing arsenic dust generated while sawing treated wood.

The costs of the proposed measures will vary. Most treatment plants already have a filter system in place, and therefore the cost of this proposed requirement would be miminal. The cost of requiring an additional vacuum stage varies from $2 to $5 per 1,000 board feet of lumber depending on the type of formulation used. The costs of the recommended final washing of the treated wood would range from $7 to $13 per 1,000 board feet of lumber, and rainfall protection sheds cost approximately $4 per 1,000 board feet of treated lumber. The cost of starting with clean wood is expected to be negligible (Mitre, 1980a).

x. Reduce Contaminants in Penta and Sodium Penta

Applicators in treatment plants that apply penta or sodium penta are exposed to hexachlorodibenzo-p-dioxin (HxCDD), a carcinogenic contaminant found in penta and sodium penta. This contaminant is formed in technical penta and sodium penta during the manufacturing process. Although most technical penta products on the market contain about 15 ppm HxCDD, technical penta can be produced with as little as 1 ppm HxCDD (e.g., Dowicide EC-7).

To reduce this source of exposure to the HxCDD contaminant in penta and sodium penta, the Agency will consider requiring that technical penta and sodium penta contain no more than 1 ppm HxCDD. By lowering the amount of HxCDD in technical penta and sodium penta, the exposure to HxCDD in all situtions would be about one-fifteenth of the present exposure. This action would reduce oncogenic risk by a factor of 15 in all situations. The

TABLE V.B-1

Oncogenic Risk Reduction Resulting from Reduction of HxCDD Contamination of Penta and Sodium Penta Products

Situation	Initial Risk	Final Risk
1. Pressure Treatment Plants		
a. General Operations	Negligible	Negligible
b. Opening Cylinder Door	6.4×10^{-4}	4.3×10^{-5}
c. Bag Emptying	7.3×10^{-3} to 1.5×10^{-2}	4.9×10^{-4} to 1.0×10^{-3}
2. Millwork and Plywood		
a. Dipping	7.1×10^{-3}	4.7×10^{-4}
b. Spraying	9.8×10^{-3}	6.5×10^{-4}
3. Sapstain Control		
a. Dipping	7.1×10^{-4}	4.7×10^{-5}
b. Spraying	1.9×10^{-3}	1.3×10^{-4}

resulting estimates of reductions in oncogenic risk are presented in Table V.B-1 for pressure and non-pressure treatment plants.

The cost of implementating this modification is based on a registered product, Dowicide EC-7, made by Dow Chemical Company, which has lower dioxin contaminants (about 1 ppm HxCDD) than other registered technical grade products on the market. Dioxin levels were reduced in this product through alterations in the manufacturing process. Other companies can also presumably develop manufacturing processes to lower the level of dioxin contaminants in their products.

4. Selection of Regulatory Options and Modifications for Treatment Plants

This section presents the selected regulatory options for all uses for which wood is treated at a treatment plant with creosote, the inorganic arsenicals, or penta and sodium penta. When the Option 2, Modifications of the Terms and Conditions of Registration, has been selected, this section will present the modifications to the terms and conditions of registration which the Agency has determined will reduce the risk of concern to an acceptable level when considered with the benefits of the pesticides' use.

Because the risks to the treatment plant workers associated with the uses of railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, sapstain control, millwork and plywood and particleboard are unacceptably high, the Agency has not selected Option 1, Continued Registation without changes. However, the benefits from the use of wood preservatives on the large number of treated wood products are extremely high. Moreover, the impacts of the cancellation of the three wood preservatives may have been underestimated since the required technology changes resulting from this cancellation scenario cannot be fully assessed. The effects of a cancellation of individual preservative chemicals would be major for certain uses because of the non-substitutability of the chemicals for specific use sites. Moreover, given the uncertainty associated with quantifying the risk for each of these chemicals and exposure situations, it is not clear whether alternative chemicals are lower in risk than the chemical of choice for any given use situation.

Based on these considerations, the Agency chose to carefully identify and implement a range of measures which would reduce exposure to each of the three wood preservatives for each of its uses. This approach maximally reduces risk while still preserving the extremely large wood preservative benefits. This section discusses the specific modifications for each wood preservative chemical, the rationale for the selection of the proposed modifications and the overall risk reduction achieved for each chemical by implementation of each modification.

a. Creosote

The risks associated with creosote have not been quantified due to the lack of data and human exposure to the individual components of creosote and the carcinogenic potential of these components.

The Agency has determined that applicators who are exposed to creosote may be subjected to a significant oncogenic risk. In addition, the Agency has also determined that the benefits of the chemical are very high (99% of all railroad ties are treated with creosote). The major alternatives to creosote are penta, copper naphthenate, and/or concrete. The properties of inorganic arsenical-treated ties make it unsuitable as an alternative to creosote-treated ties, and concrete and/or other preservative-treated ties are considerably more expensive.

Hence, if creosote were cancelled, it could be replaced by a chemical (penta) which has known adverse human health effects; since the risks to creosote are not quantifiable, it is not possible to determine if there would be a net gain in risk reduction from this measure. The Agency has determined, however, that there would be severe adverse economic impacts on both the wood treating industry and the railroad industry if creosote were cancelled.

The Agency has, therefore, selected Option 2, Modifications to the Terms and Conditions of Registration, for the uses of creosote; the selected modifications are designed to reduce the risks associated with exposure to creosote and creosote-treated wood while preserving the benefits.

b. Inorganic Arsenical Compounds

With regard to arsenic, the proposed modifications increase the teratogenic/fetotoxic margins of safety for various activities from the 100 to 500 range, which is considered marginal by the Agency, to 2,000 to 3,000 MOS range during other activities which the Agency considers acceptable.

In terms of the total oncogenic risk reduction, the initial risks are reduced from the 10^{-2} range to the 10^{-3} range. It must be noted that this risk represents an absolute worst case estimate and the Agency believes that the actual risks encounted by the inorganic arsenical wood preservative applicators (plant workers) could be at least one order of magnitude lower than those presented in this document.

Even though there is uncertainty associated with the risk numbers, the benefits from the use of inorganic arsenicals to treat wood are extremely high and a low number of applicators are involved. Based on efficacy and other performance characteristics, inorganic arsenical-treated wood is suitable for most end-uses of lumber, timber, and plywood. Inorganic arsenical-treated wood is clean, odorless, paintable, easy to handle, harmless to plants and durable compared to either penta-

or creosote-treated wood. The number of inorganic arsenical wood treatment applicators at risk ranges from 1,000 to 2,000 persons; hence 20-40 individual may contract cancer in their lifetimes (70 years) for the entire industry if no protective measures are followed. The implementation of the proposed modifications reduces the total estimated incidence of cancer to 1-2 individuals for the inorganic arsenical industry.

In view of the risk reduction which can be achieved by the proposed modifications (see Tables V.B-2, 3 and 4), the Agency has determined that cancellation is not necessary to assure that the use of the inorganic arsenical compounds will not cause unreasonable adverse effects on the environment. The Agency has selected Option 2, Modifications of the Terms and Conditions of Registration, and the Agency believes that these modifications will provide adequate protection for the applicator when these risks are considered in terms of the high benefits of the chemical.

c. Penta

The application of penta as a wood preservative poses oncogenic risks that range from 10^{-4} to 10^{-2} and fetotoxic margins of safety as low as 6. Although the Agency considers the above risks unacceptable, the Agency also realizes that these risks are based on worst case estimates of exposure. However, the Agency has determined that by implementing the selected modifications to the terms and conditions of registration, the risks would be reduced to an acceptable level (10^{-6} to 10^{-4} for oncogenic risk and margins of safety greater than 400 for fetotoxicity). Penta is a versatile chemical with high benefits from its continued use as a wood preservative. The Agency has determined that the risk reduction resulting from the selected modifications will provide adequate protection for the applicator when these risks are considered in terms of the high benefits of the chemical (see Tables V.B-5 and 6).

d. Specific Options Selected

For creosote use on railroad ties, lumber, timber and plywood, pilings, posts, crossarms, and poles, the Agency proposes continued registration with the following modifications:

-- Require Gloves (when hand dermal contact with preservatives is possible)

-- Require Neoprene Suit and Respirator (when entering cylinders)

-- Require Gloves and Respirator (when opening cylinder doors following treatment)

-- Require Proper Disposal of Protective Clothing

-- Prohibit Eating, Drinking, and Smoking During Application (designated areas will be provided in the treatment plant)

-- Classify for Restricted Use (all uses)

For the inorganic arsenical compounds the following modifications to the terms and conditions of registration have been selected:

-- Require Gloves (when hand dermal contact with preservatives is possible)

-- Require Neoprene Suit and Respirator (when entering cylinders)

-- Require Dust Mask (when working within the outside confines of the treatment plants)

-- Require Proper Disposal of Protective Clothing

-- Prohibit Eating, Drinking, and Smoking During Application (desginated areas will be provided in the treatment plant)

-- Confine Emptying and Mixing Operations to Closed Systems (powder formulations)

-- Classify for Restricted Use (all uses)

-- Reduce Arsenic Surface Residues on Treated Wood

The Agency has not selected the following modifications:

-- Require Coveralls and Gloves (when emptying containers of or mixing powder formulations).

-- Wear dust mask (when emptying bags or containers of or mixing powder formulations)

Implementation of the selected modification, Confine Emptying and Mixing Operations to a Closed System, precludes the necessity of wearing coveralls because the selected modification eliminates this source of dermal exposure. Implementation of this selected modification also eliminates this source of potential inhalation exposure; therefore, dust masks will not be required for bag emptying.

For penta or sodium penta the Agency has selected the following modifications to the terms and conditions of registration for use on railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, sapstain control, millwork and plywood, and particleboard:

-- Require Gloves (when hand dermal contact with preservatives is possible)

-- Require Gloves and Respirator (during spray application and when opening cylinder doors following treatment)

-- Require Neoprene Suit and Respirator [when entering cylinders (pressure treatment plants) and vats (non-pressure treatment plants)]

-- Require Proper Disposal of Protective Clothing

-- Prohibit Eating, Drinking, and Smoking During Application (designated areas will be provided in the treatment plant)

-- Confine Emptying and Mixing Operations to Closed Systems (powder or prilled formulations of penta or sodium penta)

-- Classify for Restricted Use (all uses)

The Agency has not selected the following modifications:

-- Require Coveralls and Gloves (when emptying bags or containers of or mixing prilled or powder formulations)

-- Reduce Contaminants in Penta and Sodium Penta

-- Require Neoprene Suit (spray operations)

-- Wear dust mask (when emptying bags or containers of prilled or powder formulations of penta or sodium penta)

Implementation of the selected modification, Confine Emptying and Mixing Operations to a Closed System, precludes the necessity of wearing coveralls because the selected modification eliminates this potential source of dermal exposure. Implementation of the selected modification also eliminates this source of potential inhalation exposure; therefore, dust masks will not be required.

The Agency has not selected the modification, Reduce Contaminants in Penta, primarily because acceptable levels of risk are achieved with the other modifications that are being proposed. While companies other than the Dow Chemical Company may have the technical capability to produce penta with only 1 ppm of HxCDD in their products, the Agency believes that requiring production conversion to the purer form of penta would cause these companies to totally cease manufacturing this wood preservative because of cost considerations.

In addition, the Agency did not select the requirement of neoprene suits for spray operations for treating wood for sapstain control and treating millwork and plywood, as the Agency believes that dermal exposure to these applicators occurs almost entirely via the hands (see Tables V.B-2 and 3 for reduction of risks provided by the use of rubberized gloves and a respirator).

The Agency has determined that implementing the modifications selected above for creosote, the inorganic arsenicals and penta will reduce the risks to acceptable levels when considered in light of the benefits of these uses, and that the use of these wood preservatives for treatment of wood will not cause unreasonable adverse effects on the environment.

TABLE V.B-2

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Gloves
1. Pressure Treatment Plants		
a. Background (total)	1.9×10^{-2}	1.9×10^{-2}
b. Bag Emptyping		
i. Inhalation	2.8×10^{-2}	2.8×10^{-2}
ii. Dermal	6.0×10^{-3}	4.4×10^{-3}
iii. Total	3.4×10^{-2}	3.2×10^{-2}
c. Mixer (concentrate)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-2}
ii. Dermal	9.8×10^{-2}	1.3×10^{-3}
iii. Total	1.17×10^{-1}	2.0×10^{-2}
d. Mixer (dilute)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-2}
ii. Dermal	7.0×10^{-3}	1.0×10^{-2}
iii. Total	2.6×10^{-2}	1.91×10^{-2}
e. Handler (treated wood)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-2}
ii. Dermal	7.0×10^{-3}	1.0×10^{-2}
iii. Total	2.6×10^{-2}	1.91×10^{-2}

TABLE V.B-2 (continued)

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Dust Mask	Gloves and Coveralls
1. Pressure Treatment Plants			
a. Background (total)	1.9×10^{-2}	3.8×10^{-3}	1.9×10^{-2}
b. Bag Emptyping			
i. Inhalation	2.8×10^{-2}	5.7×10^{-3}	2.8×10^{-2}
ii. Dermal	6.0×10^{-3}	6.0×10^{-3}	2.0×10^{-3}
iii. Total	3.4×10^{-2}	1.17×10^{-2}	3.0×10^{-2}
c. Mixer (concentrate)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	1.9×10^{-2}
ii. Dermal	9.8×10^{-2}	9.8×10^{-2}	1.0×10^{-3}
iii. Total	1.17×10^{-1}	1.0×10^{-1}	2.0×10^{-2}
d. Mixer (dilute)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	1.9×10^{-2}
ii. Dermal	7.0×10^{-3}	7.0×10^{-3}	6.8×10^{-5}
iii. Total	2.6×10^{-2}	1.1×10^{-2}	1.91×10^{-2}
e. Handler (treated wood)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	1.9×10^{-2}
ii. Dermal	7.0×10^{-3}	7.0×10^{-3}	6.8×10^{-5}
iii. Total	2.6×10^{-2}	1.1×10^{-2}	1.91×10^{-2}

TABLE V.B-2 (continued)

Lifetime Cancer Risk from Aresnic Exposure

Situation	Initial Risk	Gloves and Dust Mask	Gloves, Dust Mask, and Coveralls
1. Pressure Treatment Plants			
a. Background (total)	1.9×10^{-2}	3.8×10^{-3}	3.8×10^{-3}
b. Bag Emptyping			
i. Inhalation	2.8×10^{-2}	5.7×10^{-3}	5.7×10^{-3}
ii. Dermal	6.0×10^{-3}	4.4×10^{-3}	1.3×10^{-3}
iii. Total	3.4×10^{-2}	1.0×10^{-2}	7.0×10^{-3}
c. Mixer (concentrate)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	3.8×10^{-3}
ii. Dermal	9.8×10^{-2}	1.0×10^{-3}	1.0×10^{-3}
iii. Total	1.17×10^{-1}	4.8×10^{-3}	4.8×10^{-3}
d. Mixer (dilute)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	3.8×10^{-3}
ii. Dermal	7.0×10^{-3}	6.8×10^{-5}	6.8×10^{-5}
iii. Total	2.6×10^{-2}	3.9×10^{-3}	3.9×10^{-3}
e. Handler (treated wood)			
i. Inhalation	1.9×10^{-2}	3.8×10^{-3}	3.8×10^{-3}
ii. Dermal	7.0×10^{-3}	6.8×10^{-5}	6.8×10^{-5}
iii. Total	2.6×10^{-2}	3.9×10^{-3}	1.91×10^{-2}

TABLE V.B-2 (continued)

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Neoprene-Coated Cotton or Rubberized Overall, Jacket, Gloves and Boots, and a Respirator
1. Pressure Treatment Plants		
a. Background (total)	1.9×10^{-2}	1.9×10^{-3}
b. Bag Emptyping		
i. Inhalation	2.8×10^{-2}	1.9×10^{-3}
ii. Dermal	6.0×10^{-3}	2.2×10^{-3}
iii. Total	3.4×10^{-2}	4.1×10^{-3}
c. Mixer (concentrate)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-3}
ii. Dermal	9.8×10^{-2}	1.0×10^{-3}
iii. Total	1.17×10^{-1}	2.9×10^{-3}
d. Mixer (dilute)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-3}
ii. Dermal	7.0×10^{-3}	9.0×10^{-4}
iii. Total	2.6×10^{-2}	2.8×10^{-3}
e. Handler (treated wood)		
i. Inhalation	1.9×10^{-2}	1.9×10^{-3}
ii. Dermal	7.0×10^{-3}	9.0×10^{-4}
iii. Total	2.6×10^{-2}	2.0×10^{-3}

TABLE V.B-3

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Gloves
1. Brush-on Non-pressure Application		
i. Inhalation	Negligible	Negligible
ii. Dermal	1.2×10^{-2}	1.2×10^{-4}
iii. Total	1.2×10^{-2}	1.2×10^{-4}
2. Sawing and Fabricating		
i. Inhalation	1.4×10^{-2}	1.4×10^{-2}
ii. Gastrointestinal	1.07×10^{-1}	1.07×10^{-1}
iii. Dermal	7.9×10^{-3} to 3.9×10^{-2}	8.0×10^{-5} to 4.0×10^{-4}
iv. Total	1.3×10^{-1} to 1.6×10^{-1}	1.2×10^{-1}
3. Residents in Homes		
i. Homes with Treated Wood	$<10^{-6}$	Not Applicable
ii. Flooded Basement	$<10^{-7}$	Not Applicable

TABLE V.B-3 (continued)

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Dust Mask	Gloves and Coveralls
1. Brush-on Non-pressure Application			
i. Inhalation	Negligible	Negligible	Negligible
ii. Dermal	1.2×10^{-2}	1.2×10^{-2}	$<1.2 \times 10^{-4}$
iii. Total	1.2×10^{-2}	1.2×10^{-2}	$<1.2 \times 10^{-4}$
2. Sawing and Fabricating			
i. Inhalation	1.4×10^{-2}	2.6×10^{-3}	1.4×10^{-2}
ii. Gastrointestinal	1.07×10^{-1}		1.07×10^{-1}
iii. Dermal	7.9×10^{-3} to 3.9×10^{-2}	7.9×10^{-3} to 3.9×10^{-2}	$<8.0 \times 10^{-5}$ to $<4.0 \times 10^{-4}$
iv. Total	1.3×10^{-1} to 1.6×10^{-1}	1.1×10^{-2} to 4.2×10^{-2}	$<1.2 \times 10^{-1}$
3. Residents in Homes			
i. Homes with Treated Wood	$<10^{-6}$	Not Applicable	Not Applicable
ii. Flooded Basement	$<10^{-7}$	Not Applicable	Not Applicable

TABLE V.B-3 (continued)

Lifetime Cancer Risk from Arsenic Exposure

Situation		Initial Risk	Gloves and Dust Mask	Gloves, Dust Mask, and Coveralls
1.	Brush-on Non-pressure Application			
i.	Inhalation	Negligible	Negligible	Negligible
ii.	Dermal	1.2×10^{-2}	1.2×10^{-4}	$<1.2 \times 10^{-4}$
iii.	Total	1.2×10^{-2}	1.2×10^{-4}	$<1.2 \times 10^{-4}$
2.	Sawing and Fabricating			
i.	Inhalation	1.4×10^{-2}	2.6×10^{-3}	2.6×10^{-3}
ii.	Gastrointestinal	1.07×10^{-1}		
iii.	Dermal	7.9×10^{-3} to 3.9×10^{-2}	8.0×10^{-5} to 4.0×10^{-4}	$<8.0 \times 10^{-5}$ to $<4.0 \times 10^{-4}$
iv.	Total	1.3×10^{-1} to 1.6×10^{-1}	2.7×10^{-3} to 3.0×10^{-3}	$<2.7 \times 10^{-3}$ to $<3.0 \times 10^{-3}$
3.	Residents in Homes			
i.	Homes with Treated Wood	$<10^{-6}$	Not Applicable	Not Applicable
ii.	Flooded Basement	$<10^{-7}$	Not Applicable	Not Applicable

TABLE V.B-3 (continued)

Lifetime Cancer Risk from Arsenic Exposure

Situation	Initial Risk	Neoprene-Coated Cotton or Rubberized Overall, Jacket Gloves and Boots, and a Respirator
1. Brush-on Non-pressure Application		
i. Inhalation	Negligible	Not Applicable
ii. Dermal	1.2×10^{-2}	Not Applicable
iii. Total	1.2×10^{-2}	Not Applicable
2. Sawing and Fabricating		
i. Inhalation	1.4×10^{-2}	Not Applicable
ii. Gastrointestinal	1.07×10^{-1}	Not Applicable
iii. Dermal	7.9×10^{-3} to 3.9×10^{-2}	Not Applicable
iv. Total	1.3×10^{-1} to 1.6×10^{-1}	Not Applicable
3. Residents in Homes		
i. Homes with Treated Wood	$<10^{-6}$	Not Applicable
ii. Flooded Basement	$<10^{-7}$	Not Applicable

TABLE V.B-4

Impact of Modifications on Teratogenic/Fetotoxic Margins of Safety for Arsenic

Situation	Initial Risk	Gloves
1. Pressure Treatment Plants		
a. Background	500	500
b. Bag Emptying	294	310
c. Mixer (concentrate)	135	487
d. Mixer (dilute)	417	499
e. Handler (treated wood)	417	499
2. Brush-on Non-pressure Application	1,667	170,000
3. Sawing and Fabricating	106-128	135
4. Residents in Homes		
i. Homes with Treated Wood	128,200	Not Applicable
ii. Flooded Basement	1,923	Not Applicable

TABLE V.B-4 (continued)

Impact of Modifications on Teratogenic/Fetotoxic Margins of Safety for Arsenic

Situation	Initial Risk	Dust Mask	Gloves and Coveralls
1. Pressure Treatment Plants			
a. Background	500	2,500	>500
b. Bag Emptyping	294	Not Applicable	326
c. Mixer (concentrate)	135	Not Applicable	>487
d. Mixer (dilute)	417	Not Applicable	>499
e. Handler (treated wood)	417	Not Applicable	>499
2. Brush-on Non-pressure Application	1,667	Not Applicable	>170,000
3. Sawing and Fabricating	106-128		140
4. Residents in Homes			
i. Homes with Treated Wood	128,200	Not Applicable	Not Applicable
ii. Flooded Basement	1,923	Not Applicable	Not Applicable

TABLE V.B-4 (continued)

Impact of Modifications on Teratogenic/Fetotoxic Margins of Safety for Arsenic

Situation	Initial Risk	Gloves and Dust Mask	Gloves, Dust Mask, and Coveralls
1. Pressure Treatment Plants			
a. Background	500	2,500	Not Applicable
b. Bag Emptyping	294	1,214	Not Applicable
c. Mixer (concentrate)	135	2,203	Not Applicable
d. Mixer (dilute)	417	2,479	Not Applicable
e. Handler (treated wood)	417	2,479	Not Applicable
2. Brush-on Non-pressure Application	1,667	Not Applicable	Not Applicable
3. Sawing and Fabricating	106-128	3,330	3,520
4. Residents in Homes			
i. Homes with Treated Wood	128,200	Not Applicable	Not Applicable
ii. Flooded Basement	1,923	Not Applicable	Not Applicable

TABLE V.B-4 (continued)

Impact of Modifications on Teratogenic/Fetotoxic Margins of Safety for Arsenic

Situation	Initial Risk	Neoprene-Coated Cotton or Rubberized Overall, Jacket Gloves and Boots, and a Respirator
1. Pressure Treatment Plants		
a. Background	500	5,000
b. Bag Emptyping	294	2,724
c. Mixer (concentrate)	135	3,937
d. Mixer (dilute)	417	4,916
e. Handler (treated wood)	417	4,916
2. Brush-on Non-pressure Application	1,667	Not Applicable
3. Sawing and Fabricating	106-128	31,250 to 20,833
4. Residents in Homes		
i. Homes with Treated Wood	128,200	Not Applicable
ii. Flooded Basement	1,923	Not Applicable

TABLE V.B-5

Lifetime Cancer Risk From HxCDD Exposure

Situation	Initial Risk	Gloves	Gloves & Coveralls
Pressure Treatment:			
General Operations	Negligible	Negligible	Negligible
Opening Cylinder Door	6.4×10^{-4} + dermal	6.4×10^{-4}	6.4×10^{-4}
Bag Emptying	7.3×10^{-3} to 1.5×10^{-2}	7.1×10^{-3} to 1.3×10^{-2}	6.6×10^{-3} to 8.2×10^{-3}
Millwork & Plywood (Dip)	7.1×10^{-3}	7.1×10^{-5}	7.1×10^{-5}
Millwork & Plywood (Spray)	9.8×10^{-3}	1.7×10^{-3}	1.7×10^{-3}
Sapstain Control (Dip)	7.1×10^{-4}	7.1×10^{-6}	7.1×10^{-6}
Sapstain Control (Spray)	1.9×10^{-3}	3.4×10^{-4}	3.4×10^{-4}
Home & Farm: During Application	1.0×10^{-6} to 1.3×10^{-4}	1.0×10^{-8} to 1.3×10^{-6}	1.0×10^{-8} to 1.3×10^{-6}

TABLE V.B-5 (continued)

Lifetime Cancer Risk from HxCDD Exposure

Situation	Initial Risk	Respirators	Gloves & Respirators
Pressure Treatment:			
General Operations	Negligible	Negligible	Negligible
Opening Cylinder Door	6.4×10^{-4} + dermal	6.4×10^{-5} + dermal	6.4×10^{-5}
Bag Emptying	7.3×10^{-3} to 1.5×10^{-2}	1.5×10^{-3} to 9.4×10^{-3}	1.3×10^{-3} to 6.9×10^{-3}
Millwork & Plywood (Dip)	7.1×10^{-3}	7.1×10^{-3}	7.1×10^{-5}
Millwork & Plywood (Spray)	9.8×10^{-3}	8.3×10^{-3}	2.4×10^{-4}
Sapstain Control (Dip)	7.1×10^{-4}	7.1×10^{-4}	7.1×10^{-6}
Sapstain Control (Spray)	1.9×10^{-3}	1.6×10^{-3}	4.8×10^{-5}
Home & Farm: During Application	1.0×10^{-6} to 1.3×10^{-4}	1.0×10^{-6} to 1.3×10^{-4}	1.0×10^{-8} to 1.3×10^{-6}

TABLE V.B-5 (continued)

Lifetime Cancer Risk from HxCDD Exposure

Situation	Initial Risk	Neoprene-Coated Cotton or Rubberized Overalls, Jacket, Gloves and Boots	Neoprene-Coated Cotton or Rubberized Overalls, Jacket, Gloves and Boots, and a Respirator
Pressure Treatment:			
General Operations	Negligible	Negligible	Negligible
Opening Cylinder Door	6.4×10^{-4} + dermal	6.4×10^{-4}	6.4×10^{-5}
Bag Emptying	7.3×10^{-3} to 1.5×10^{-2}	6.6×10^{-3} to 8.2×10^{-3}	8.2×10^{-4} to 2.4×10^{-3}
Millwork & Plywood (Dip)	7.1×10^{-3}	7.1×10^{-5}	7.1×10^{-5}
Millwork & Plywood (Spray)	9.8×10^{-3}	1.7×10^{-3}	2.4×10^{-4}
Sapstain Control (Dip)	9.1×10^{-4}	7.1×10^{-6}	7.1×10^{-6}
Sapstain Control (Spray)	1.9×10^{-3}	3.4×10^{-4}	4.8×10^{-5}
Home & Farm: During Application	1.0×10^{-6} to 1.3×10^{-4}	1.0×10^{-8} to 1.3×10^{-6}	1.0×10^{-8} to 1.3×10^{-6}

TABLE V.B-6

Fetotoxic Margins of Safety for Penta Exposure

Situation	Initial Risk	Gloves	Gloves & Coveralls
Pressure Treatment:			
General Operations	730	730	730
Opening Cylinder Door	150 + dermal	150	150
Bag Emptying	6.4 to 13	7.7 to 14	12 to 15
Millwork & Plywood (Dip)	5.9	210	210
Millwork & Plywood (Spray)	10	57	57
Sapstain Control (Dip)	59	6,000	6,000
Sapstain Control (Spray)	50	290	290
Home & Farm: During Indoor Application	6 to 400	360 to 900	360 to 900
Home & Farm: During Outdoor Application	6 to 650	560 to 7,100	560 to 7,100

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TABLE V.B-6 (continued)

Fetotoxic Margins of Safety for Penta Exposure

Situation	Initial Risk	Respirators	Gloves & Respirators
Pressure Treatment:			
General Operations	730	7,300	7,300
Opening Cylinder Door	150 + dermal	1,500 + dermal	1,500
Bag Emptying	6.4 to 13	10 to 64	14 to 78
Millwork & Plywood (Dip)	5.9	6	510
Millwork & Plywood (Spray)	10	12	400
Sapstain Control (Dip)	59	60	6,000
Sapstain Control (Spray)	50	590	2,000
Home & Farm: During Indoor Application	6 to 400	6 to 660	560 to 8,100
Home & Farm: During Outdoor Application	6 to 650	6 to 710	600 to >10,000

TABLE V.B-6 (continued)

Fetotoxic Margins of Safety for Penta Exposure

Situation	Initial Risk	Neoprene-Coated Cotton or Rubberized Overalls, Jacket, Gloves and Boots	Neoprene-Coated Cotton or Rubberized Overalls, Jacket, Gloves and Boots, and a Respirator
Pressure Treatment:			
General Operation	730	730	7,300
Opening Cylinder Door	150 + dermal	150	1,500
Bag Emptying	6.4 to 13	12 to 15	41 to 120
Millwork & Plywood (Dip)	5.9	210	510
Millwork & Plywood (Spray)	10	57	400
Sapstain Control (Dip)	59	6,000	6,000
Sapstain Control (Spray)	50	290	2,000
Home & Farm: During Indoor Application	6 to 400	360 to 900	560 to 8,100
Home & Farm: During Outdoor Application	6 to 650	560 to 7,100	600 to >10,000

C. Use Categories: Pesticides Applied Outside of Treatment Plants

The following discussions refer to those uses for which application of the wood preservative does not take place in a treatment plant. The uses are poles-groundline, home and farm, and commercial brush-on applications of the inorganic arsenicals.

Poles-groundline application refers to the treatment of telephone poles in a small area above and just below the groundline. Penta or creosote or a mixture of penta and creosote, are used for this purpose. The use category of home and farm includes all applications of penta and creosote to wood by the homeowner or farmer and by commercial applicators. Commercial brush-on application refers to the application of the inorganic arsenicals to the cut-ends of treated wood, an activity which usually occurs at construction sites; these inorganic arsenical formulations are not generally available for purchase by the homeowner or farmer.

1. Summary of Risks

a. Poles-Groundline

i. Creosote

As discussed in Sections II.B.5 and II.B.6, creosote poses oncogenic and mutagenic risks to humans; however this risk has not been quantified. There are very little data available regarding a workers' exposure to all of the specific oncogenic or mutagenic components of creosote. While the level of risk cannot be quantified with the exposure information available, there are many reports of incidences of skin cancer among workers who apply creosote.

ii. Penta

Penta and its contaminants pose a risk of oncogenic and fetotoxic effects in humans.

Dermal exposure to the workers who apply penta for poles-groundline use occurs during the handling and application of the wet paste. Although the Agency is unable to quantify the exposure to poles-groundline applicators, the Agency believes this exposure will occur primarily through the hands. Due to the nature of the operation, however, some splattering of treatment solution onto other areas of exposed skin may also occur.

b. Home and Farm

i. Creosote

In addition to the potential risks associated with the application processes discussed in the prior sections, there are occasions when creosote is also sprayed onto the surfaces of wood. While the applicator's exposure during this process has not been quantified, the Agency believes that exposure during a spray operation will be greater than that experienced during brush-on or dip applications.

ii. Penta

Penta and its contaminants pose a risk of oncogenic and fetotoxic effects in humans.

The amount of dermal exposure to penta during home and farm applications is dependent upon the care with which the product is applied. The Agency estimates that homeowners may spill amounts of penta formulation ranging from 1 drop (0.05 ml) to 6 ml on their skin during one brush-on application period. These applicators may also be exposed to penta via inhalation. In addition to the dipping and brushing of these penta products, these preservatives are occasionally sprayed onto the surfaces of wood. Although the Agency has not quantified the applicator exposure during this type of application, data indicate that this exposure is likely to be much greater than that encountered during brush-on or dip applications. The Agency has estimated that the total lifetime oncogenic risks to the home and farm applicators for penta use ranges from 1.0×10^{-6} to 1.3×10^{-4} during application. The fetotoxic MOS ranges from 6 to 400 for indoor application and from 6 to 650 for outdoor application.

c. Brush-On Applications of the Inorganic Arsenicals

The exposure to the inorganic arsenicals by commercial brush-on treatment applications is caused by spilling or otherwise coming in contact with the liquid formulations. The dermal exposure in this situation is estimated to be 3 ug/kg/day, and the lifetime dermal oncogenic risk to brush-on applicators is 1.2×10^{-2}. The teratogenic/fetotoxic MOS is estimated to be 1,667. The Agency has assumed that inhalation exposure would be negligible, as brush-on treatments are applied outdoors using very small volumes of treatment solution.

2. Summary of Benefits

a. Poles-Groundline

The poles-groundline treatment of in-place utility poles is a small, but an increasingly important segment of the wood treatment industry. In poles-goundline treatment, wood preservatives are applied to a previously installed pressure treated pole over a section covering the six inches above and the six inches below the ground level of the pole. This treatment can delay decay and subsequent pole failure for 20 years or more.

The two major formulations of commercial poles-groundline treatments marketed in the United States contain both creosote and penta; one of these formulations has a high creosote content and the other a high penta content (this product also contains sodium fluoride). Currently, the high creosote formulation is used for about 66% of all poles-groundline treatments and the high penta content product is used for about 33% of the poles-groundline treatments. The number of utility poles receiving poles-groundline treatment in the United States was estimated to be approximately 1 million in 1978.

The Agency has evaluated the benefits of penta and creosote for poles-groundline treatments and has determined the economic impacts if penta, creosote, or both were cancelled for this use. If either penta or creosote were cancelled, there would be minor adverse first year and annual long-term impacts because the remaining registered wood preservative would be substituted for the cancelled one.

If both penta and creosote were cancelled for the groundline treatment of poles, there would be a first year cost decrease of $10 million to $12 million, but an average annual ("annualized") cost increase of about $36.8 million. If the current level of groundline treatment doubles in the next 5 years, as projected by some experts, the increase in annualized pole replacement costs would exceed $70 million. Thus, the cancellation of both creosote and penta for poles-groundline treatment would result in a major adverse economic impact.

b. Home and Farm

Penta and creosote solutions are applied by homeowners, farmers, and, to some extent, by on-the-job carpenters by brushing, rolling, dipping, soaking or spraying methods. Typical treated wood items include decks, siding, millwork, lumber, fences, shingles, outdoor furniture and other miscellaneous wood products. These non-pressure applications of penta and creosote extend the useful service life of wood in aboveground applications and provide limited protection for wood in contact with the ground. About 1.6 million pounds of penta and 2.0 million pounds of creosote are used around homes and farms to protect various wood structures and products exposed to natural elements.

There are several alternative wood preservatives registered for home and farm uses, the most common being copper naphthenate, copper-8-quinolinolate (Cu-8), zinc naphthenate and tributyltin oxide (TBTO). Copper naphthenate is effective under certain conditions but its overall performance is questionable, it imparts a green color to the wood, makes a poor base for paint and leaves the wood difficult to finish naturally. Zinc naphthenate, which imparts a colorless finish to wood, is considered less efficacious than copper naphthenate. The TBTO formulations are colorless in solution and leave the wood clear and paintable. This chemical has some known merit for protecting wood aboveground, but is ineffective for ground contact use. Registered Cu-8 formulations have demonstrated less effectiveness in controlling rot and decay than either creosote, the inorganic arsenicals or penta. Alternatives to non-pressure treatment with chemical agents include leaving the wood untreated, using nonwood materials (e.g., aluminum and concrete), purchasing lumber which has been pressure treated, or using a naturally resistant wood species; natural wood is, however, in short supply.

The Agency has evaluated the benefits of the home and farm uses of penta and creosote and has determined that there would be a minor economic impact consisting of a slight increase in preservative cost if creosote or penta were cancelled. The chemical alternatives (copper naphthenate, copper-8-quinolinolate, zinc naphthenate and tributyltin oxide) are currently available to homeowners and farmers, but at prices which are somewhat higher than the price of penta or creosote. These alternatives do not have the wide range of control characteristic of penta or creosote. Non-wood materials such as aluminum and concrete can replace treated wood in some circumstances at comparable prices; the comparability of cost does not, however, take into account the aesthetic value of wood. The price of pressure treated lumber is slightly higher than lumber treated by brush-on or dip applications, but the pressure treatments would provide better protection to the wood. However, the inorganic arsenical-treated lumber can only be considered a partial substitute for the home and farm uses of penta and creosote since pressure treated lumber is not an alternative for all non-pressure home and farm uses.

c. Brush-On Applications of the Inorganic Arsenicals

The non-pressure treatments with the inorganic arsenicals are not generally available to home and farm applicators because of current marketing practices. About 2,000 to 3,000 gallons of 3% inorganic arsenical solution is sold annually for field treatment (outdoor applications only) of cut-ends of inorganic arsenical-treated wood. The Agency has determined that due to the small amounts of the inorganic arsenicals used for commercial use, there would be a minor adverse economic impact if inorganic arsenical formulations were cancelled for commercial brush-on applications because either penta or creosote are available as alternatives for this purpose.

3. Risk/Benefit Analysis

a. Consideration of Regulatory Options

The Agency has determined, based on the risk and benefit data, that the non-pressure treatment of wood for poles-groundline and home and farm uses with creosote and/or penta, or commercial brush-on applications of the inorganic arsenicals pose unreasonable adverse effects on the environment. Therefore, the registration of these wood preservatives cannot be simply continued for these uses. Cancellation of these wood preservatives for each use is, however, not a desirable option because the alternatives (e.g., TBTO and Cu-8) have limited efficacy and moderate economic impacts could result if the three wood preservatives were cancelled. Also, cancellation of one of the three wood preservatives for a specific use is not likely to appreciably reduce risks since the risks from the alternatives may be equal or greater. Therefore, the Agency will consider Option 2, Modification of the Terms and Conditions of Registration, to determine if risk reduction measures can reduce the risk to acceptable levels. In the following sections, the Agency will evaluate the impacts of the modifications under consideration on risk reduction and on the benefits of use. For those situations where the risk cannot be reduced to acceptable levels the Agency will select Option 3, Cancellation.

b. Risk/Benefit Impacts of Modifications Under Consideration for Poles-Groundline, Home and Farm, and Brush-On Applications of the Inoranic Arsenicals

i. Gloves

During the poles-groundline treatment (creosote and penta), home and farm applications (creosote and penta) and commercial brush-on treatments with the inorganic arsenicals, the Agency has determined that exposure to the three wood preservatives occurs through the hands. To reduce the risk caused by this route of exposure, the Agency will consider requiring that all applicators using these pesticides for poles-groundline, home and farm, and commercial brush-on applications of the inorganic arsenicals wear gloves impervious to the pesticides (e.g., rubber).

While there is no quantitative estimate for the reduction in risk achieved by the use of gloves for poles-groundline use situations, the wearing of gloves is expected to reduce the hand dermal exposure to these chemicals (penta and/or creosote) by 99% (Kozak, 1980).

Implementation of this modification for home and farm application will reduce the hand dermal exposure to creosote and penta by 99%. The oncogenic risk for both indoor and outdoor applications of penta will thus be reduced from a range of 1.0×10^{-6} to 1.3×10^{-4} to a range of 1.0×10^{-8} to 1.3×10^{-6}. The MOS for fetotoxicity of penta will be increased from a range of 6 to 400 to a range of 360 to 900 for indoor application, and from a range of 6 to 650 to a range of 560 to 7,100 for outdoor application. No quantitative risks estimates have been obtained for creosote.

During commerical brush-on treatments of the inorganic arsenicals to wood, the exposure to the applicator is through hand dermal exposure. Wearing gloves will reduce the dermal oncogenic risk from 1.2×10^{-2} to 1.2×10^{-4} and increase the teratogenic/fetotoxic MOS from 1,667 to 170,000.

The annual cost of this option is $60 to $312 per applicator for poles-groundline and for commercial brush-on inorganic arsenicals, and would be insignificant for home and farm applicators who would only apply preservatives sporadically during the year.

ii. Disposable Coveralls and Gloves

It is likely that, during the treatment of poles-groundline and the brush-on applications of over-the-counter products of creosote or penta on the home or farm, some spillage or splattering may occur on the arms and legs as well as the hands. Therefore, the Agency will consider requiring commercial applicators to wear protective clothing, such as disposable coveralls (e.g., nitrile or polyethylene) and gloves (e.g., rubber). Private applicators (e.g., homeowners) would be required to wear tightly-woven long sleeved cotton coveralls and gloves (e.g., rubber) since disposable coveralls are not readily available to them.

While the primary exposure to the inorganic arsenicals during the commercial brush-on treatments results from hand dermal exposure, some spillage or splattering may occur on the arms and legs. Hence, the Agency will also consider requiring brush-on applicators of the inorganic arsenicals to wear disposable coveralls (e.g., nitrile or polyethylene) and gloves (e.g., rubber). This modification will reduce risks to a greater degree than the risk reduction resulting from gloves alone. However, the Agency has not quantified these additional exposure reductions.

The cost of implementing this modification will be about $20 to $40 per applicator for coveralls annually for poles-groundline and home and farm applicators. The combined annual cost of coveralls and gloves would range from $28,000 to $123,200 for the poles-groundline industry assuming that this protective clothing is not currently supplied to these applicators.

iii. Require Neoprene-Coated Cotton or Rubberized Overall, Jacket, Boots and Gloves, and a Respirator

During spray operations of penta and creosote by home and farm applicators to treat wood, the Agency has determined that there is a potential for dermal and inhalation exposure. Therefore, the Agency has determined that some degree of risk exists during spray applications. However, these risks have not been quantified.

To reduce the risks resulting from spray applications, the Agency will consider requiring all applicators spraying penta or creosote to wear a neoprene-coated cotton or rubberized overall jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use. The respirator will reduce inhalation exposure by 90% and the use of the gloves, boots, overalls, and jackets will reduce total dermal exposure by 80%.

Although the cost of a respirator ranges from $300 to $700 per applicator and the annual cost of protective clothing ranges from $70 to $392 per applicator, the Agency believes the economic impact on commercial applicators will not be great.

The economic impact of this modification is expected to be severe, however, for many non-commercial applicators (e.g., homeowners).

iv. Require Proper Disposal of Protective Clothing

Although the Agency has not quantified the risks, there are potential risks from penta, the inorganic arsenicals, and creosote sticking to clothing and shoes, and being transported into the home following poles-groundline, home and farm, and brush-on applications of the inorganic arsenicals by the commerical applicators. This exposure could pose a risk to the applicators' families.

To reduce risks from this potential exposure, the Agency will consider requiring that poles-groundline applicators dispose of worn-out protective clothing by following the instructions for pesticide container disposal. For the home and farm commercial applicators and commercial brush-on applications of the inorganic arsenicals, the Agency will also consider requiring applicators to dispose of worn-out protective clothing in accordance with pesticide container disposal.

With regard to the commercial home and farm, and brush-on applications of the inorganic arsenicals, implementation of this modification is not expected to have a significant cost. The economic impacts on the poles-groundline applicators for disposing of worn-out protective clothing are minor.

V. Prohibit Eating, Drinking and Smoking During Application

Although the risks due to accidental ingestion of wood preservatives by smoking, drinking, or eating during poles-groundline treatment, home and farm applications, or commerical brush-on applications of the inorganic arsenicals have not been quantified, the Agency has determined that there is a potential for adverse human health effects in these use situations. To eliminate risks from this potential exposure, the Agency will consider the prohibition of eating, drinking, and smoking during these applications.

The costs of implementing this modification have not been quantified, but they are not expected to be large.

vi. Classify for Restricted Use

The Agency has no means of quantitatively determining the risk attributable to improper pesticide handling during poles-groundline application, home and farm applications, and during commerical brush-on treatments of the inorganic arsenicals. However, the Agency believes that education and training would increase the care with which wood preservatives are handled, and as a result the total exposure to these pesticides will be reduced by some finite amount. To assure proper handling of these chemicals, the Agency will consider classifying all home and farm formulations of creosote and formulations containing more than 5% penta as restricted use pesticides. The Agency will also consider classifying creosote and penta formulations for poles-groundline treatment and the inorganic arsenical formulations for commercial brush-on treatments as restricted use chemicals. This modification has the potential to reduce exposure via educational measures.

The Agency believes that with proper labeling, penta formulations containing 5% or less penta can be handled safely by homeowners and farmers. However, the use of concentrated penta formulations, which must be diluted for use, may result in a large potential exposure. Thus, while farmers who become certified applicators may still purchase the concentrates from which the diluted formulations can be prepared for use on large amounts of wood, only concentrations of 5% or less penta (ready-to-use products) will be available to the non-certified homeowner.

The restricted use classification for creosote products, penta formulations greater than 5%, and the inorganic arsenicals will result in a cost per applicator or crew (poles-groundline) which ranges from $25 to $50 per certification. This modification would require only one applicator per crew to be certified.

vii. Limit Application of Wood Preservatives to Outdoor Areas

The Agency believes that applying a volatile chemical such as penta or creosote or using the treated wood in an interior area will result in inhalation exposure to the applicator. It is a common practice for individuals to paint the interior of barns or other enclosed areas (inside homes) with creosote or penta to preserve the wood or to prevent horses and farm animals from chewing on the wood.

To reduce the exposure resulting from interior applications of the creosote and penta, the Agency will consider limiting the applications of creosote and penta to the outdoors. Outdoor application is defined in FIFRA as any pesticide application or use that occurs outside enclosed man-made structures or the consequences of which extend beyond enclosed man-made structures.

The economic impacts resulting from implementation of this modification have not been quantified, but are not expected to be large.

viii. Reduce Contaminants in Penta

One of the toxic contaminants of penta is hexachlorodibenzo-p-dioxin (HxCDD), a potent oncogen. Although most technical penta products on the market contain about 15 ppm HxCDD, technical penta can be produced with as little as 1 ppm HxCDD. The Agency will consider requiring that technical penta contain no more than 1 ppm HxCDD. The resultant exposure to HxCDD to poles-groundline and home and farm applicators would be about one-fifteenth of the present exposure. This modification, therefore, would reduce oncogenic risk by a factor of 15. The oncogenic risk for both indoor and outdoor applications of penta for home and farm uses will thus be reduced from range of 1.0×10^{-6} to 1.3×10^{-4} to a range of 6.7×10^{-8} to 8.7×10^{-6}. Due to a lack of data, the implementation of this modification for poles-groundline would reduce the oncogenic risk of HxCDD by a factor of 15.

A registered product, Dowicide EC-7, made by Dow Chemical Company, has lower dioxin contaminants than other registered technical grade penta products on the market. Dioxin levels were reduced in this product through alterations in the manufacturing process. Presumably, other companies can also develop manufacturing processes to lower the level of dioxin contaminants in their products.

4. Selected Modifications for Poles-Groundline (Creosote and Penta), Home and Farm (Creosote and Penta), and Brush-on Applications of the Inorganic Arsenicals

This section presents the selected regulatory options for creosote and penta used in poles-groundline, home and farm, and in commercial brush-on treatments of the inorganic arsenicals. When Option 2, Modification of the Terms and Conditions of Registration, has been selected, this section will present the modifications to the terms and conditions of registration which the Agency has determined will reduce the risk of concern to an acceptable level when considered with the benefits of the pesticide use.

Because the risks to the applicator associated with poles-groundline, home and farm, and commercial brush-on treatments are unacceptably high, the Agency has not selected Option 1, Continued Registration without changes. In evaluating the risk reductions which can be achieved through the modification to the terms and conditions of registration, the Agency believes that the risks in most cases can be reduced by one to two orders of magnitude. This reduction results in a situation in which the benefits, which are high, outweigh the risks. However, the Agency has determined that the spray application method in the home and farm use category, Option 3, Cancellation, is the option of choice. This determination is discussed following the section which presents the modifications to the terms and conditions of registration for home and farm use.

a. Poles-Groundline

This section presents the modifications to the terms and conditions of registration which the Agency has selected for creosote and penta formulations for poles-groundline application.

-- Require Gloves (when hand dermal contact with preservatives is possible)

-- Require Disposable Coveralls and Gloves (when dermal contact with preservatives is possible)

-- Require Proper Disposal of Protective Clothing

-- Prohibit Eating, Drinking, and Smoking During Application

-- Classify for Restricted Use

Although most of the exposure reduction from these modifications has not been quantified, the Agency believes that implementation of these modifications will reduce risks to the applicators to acceptable levels when considered in light of the benefits of use, and that the poles-groundline use of creosote and penta will not cause unreasonable adverse effects on the environment.

The Agency has not selected the modification, Reduce Contaminants in Penta, primarily because acceptable levels of risk are achieved with the other modifications that are being proposed. While companies other than the Dow Chemical Company may have the technical capability to produce penta with only 1 ppm of HxCDD in their products, the Agency believes that requiring production conversion to the purer form of penta would cause these companies to totally cease manufacturing this wood preservative because of cost considerations.

b. Home and Farm

For home and farm use of creosote and penta, the Agency has selected the following modifications to the terms and conditions of registration:

- -- Require Gloves (when hand dermal contact with preservatives is possible)
- -- Require Coveralls and Gloves (when dermal contact with preservative is possible; disposable coveralls for commercial applicators and tightly-woven long sleeved cotton coveralls for private applicators)
- -- Require Neoprene-coated Cotton or Rubberized Overall Jacket, Gloves and Boots, and Respirator (during spraying applications, commercial applicators only)
- -- Require Proper Disposal of Protective Clothing (for commercial applicators only)
- -- Prohibit Eating, Drinking, and Smoking During Application
- -- Classify for Restricted Use (except for formulations containing 5% or less penta)

-- Classify All Creosote Formulations for Restricted Use

-- Limit Application to Outdoors

Although most of the exposure reduction from these modifications have not been quantified, the Agency believes that implementation of these modifications will reduce risks to the applicators to an acceptable level when considered in light of the benefits of use, and that the home and farm uses will not cause unreasonable adverse effects on the environment.

The Agency has not selected the modification, Reduce Contaminants in Penta, primarily because acceptable levels of risk are achieved with the other modifications that are being proposed. While companies other than the Dow Chemical Company may have the technical capability to produce penta with only 1 ppm of HxCDD in their products, the Agency believes that requiring production conversion to the purer form of penta would cause these companies to totally cease manufacturing this wood preservative because of cost considerations.

-- Cancellation: Spraying by Homeowner of Concentrations of 5% or less of Penta

Home and farm products containing creosote or penta are typically applied by brush, dip, or spray methods. The Agency has evidence indicating that the spray operation presents, by far, the greatest opportunity for exposure to the applicator.

The Agency has selected the modification that all home and farm products containing greater than 5% penta and products containing creosote be restricted to certified applicators. To reduce the potential for high exposure to non-certified applicators (homeowners) applying the unrestricted penta products available for retail sale, the Agency has determined that Option 3, Cancellation, is the option of choice for the spraying method of applicaton. Therefore, the Agency will propose cancellation for the spraying of home and farm products containing penta in concentrations of 5% or less. This cancellation is not expected to result in a severe burden on applicators of these products because brush-on and dip methods of application are still available.

c. Brush-On Applications of the Inorganic Arsenicals

During commercial brush-on applications of the inorganic arsenicals, the Agency has selected the following modifications to the terms and conditions of registration:

-- Require Gloves (when hand dermal contact with preservatives is possible)

-- Require Disposable Coveralls and Gloves (when dermal contact with preservatives is possible)

-- Require Proper Disposal of Protective Clothing

-- Prohibit Eating, Drinking, and Smoking During Application

-- Classify for Restricted Use

The Agency has determined that implementing these modifications will reduce the risk of use of these pesticides to acceptable levels when considered in light of the benefits and that the use of the inorganic arsenicals will not cause unreasonable adverse effects on the environment for commercial brush-on applications.

D. End-uses of Treated Wood

The previous sections of this part have addressed the potential exposures to applicators from the application of the wood preservatives creosote, the inorganic arsenicals, and penta. The end-use risks which are presented in this section arise from human exposure to the pesticides after they have been applied to the wood. Because of the vast number of end-uses of treated wood, there are many opportunities for exposure to these pesticides via the treated wood (e.g., contamination of foodstuffs). The populations at risk include construction workers, home repairmen, residents of pesticide-treated dwellings, and the general public, many of whom probably do not realize that they are being exposed to a pesticide.

1. Summary of Risks

a. Creosote

Although the risks have not been quantified, the Agency believes that potential human exposure to creosote-treated wood may occur in the following use categories: railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, and wood that has been treated during home and farm applications. Examples of populations exposed dermally or through inhalation are the workmen laying the railroad ties, utility linemen working on utility poles and crossarms, construction workers installing marine pilings, and homeowners and farmers installing fence posts, or contacting creosote-treated barns. Creosote-treated wood tends to "bleed"; consequently, individuals handling creosote-treated wood would be exposed to creosote via the hands.

Because creosote has been shown to be oncogenic and mutagenic, the Agency believes there is a definite, although unquantifiable, risk to individuals who dermally contact creosote-treated wood, breathe creosote fumes in enclosed areas, consume food or water which has been in contact with creosote-treated wood, or saw creosote-treated wood.

b. Inorganic Arsenical Compounds

The potential human exposure to inorganic arsenical-treated wood may occur in the following use categories: lumber, timber and plywood, pilings, posts, crossarms, and poles.

Potential dermal exposure and inhalation exposure may occur to persons involved in handling and sawing pestcide-treated wood, contacting treated playground equipment or other treated wooden structures with unprotected skin, breathing arsenic dust in enclosed areas or consuming food or water which has been in contact with inorganic arsenical-treated wood.

The Agency has determined that during the sawing operations of treated wood, preservative-bearing sawdust tends to become airborne, providing an opportunity for inhalation, gastrointestinal, and widespread dermal exposure. During the sawing and handling of inorganic arsenical-treated wood, the total lifetime oncogenic risks range from 1.3×10^{-1} to 1.6×10^{-1}. The teratogenic/fetotoxic margins of safety for this construction activity range from 106 to 128. This oncogenic risk is composed of dermal, gastrointestinal and inhalation components. The dermal and gastrointestional exposure component, which is primarily related to the incidence of skin cancer risk*, is estimated to be 1.4 x 10^{-1}. The inhalation exposure component, which is primarily related to the incidence of lung cancer risk, is estimated to be 1.4 x 10^{-2}.

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* Gastrointestinal absorption has been shown to cause abnormal skin pegmentation and skin tumors.

The Agency has estimated the exposure that would result from a person cleaning a basement after seven days of continuous flooding. Dermal and inhalation exposure would result from the leaching of arsenic from the lumber, timber and plywood and the subsequent arsenic dust formed after the flood receeded. The Agency estimates that the total lifetime oncogenic risk from the clean up of one flood would be about 10^{-7}. The teratogenic/fetotoxic MOS for this situation would be 1,923.

The Agency has no monitoring data on exposure to arsenic for children playing on arsenically treated playground equipment or persons who inadvertently contact arsenically treated wood surfaces such as handrails, sun decks, park benches, stadium seats, and boardwalks.

c. Penta

Potential human exposure to penta-treated wood may occur in the following use categories: railroad ties, lumber, timber and plywood, pilings, posts, crossarms, poles, sapstain control, millwork and plywood, particleboard, and wood that has been treated following home and farm applications. Examples of populations exposed, dermally and through inhalation, are persons handling and sawing the penta-treated wood, lineman installing and maintaining utility poles and crossarms, construction workers

installing foundation pilings, and homeowners and farmers installing fence posts or contacting penta-treated barns. The general public may also be inadvertantly exposed through contact with treated park benches, stadium seats, handrails and fences as well as through food residues of penta from food contact with penta-treated wood (e.g., packing crates, feed bins, grape stakes, mushroom flats). Penta-treated particleboard is used in kitchens, where there may be exposure via inhalation and via contamination of food.

Following application indoors, inhalation exposure to penta may continue to occur for a considerable length of time. Based on measured air levels, the Agency has calculated the inhalation exposure to a resident of a home treated on the inside with penta to be about 8 ug/kg/day and is considered negligible for HxCDD due to its lower vapor pressure relative to that of penta. This exposure translates into a fetotoxic MOS for about 380.

The Agency was unable to estimate the level of dermal exposure via the handling of penta-treated wood because of the absence of data on dermal absorption rates and the limited data on surface residue levels of penta, its contaminants, and its breakdown products.

2. Summary of Benefits

The Agency has evaluated the economic impact of the cancellation of one or more of the wood preservative agents in terms of the cost to end-users of substituting creosote-, inorganic arsenical- or penta-treated wood with wood treated with the remaining registered preservative(s) or with alternative materials (e.g., steel, concrete).

The three wood preservatives, creosote, the inorganic arsenical compounds, and penta, are usually the major substitutes for each other in the treatment of wood. While there are some minor alternatives, including certain species of untreated wood (e.g., redwood and western red cedar), other chemical preservatives (e.g., copper naphthenate), and structural alternatives (e.g., concrete and steel), these alternatives are all more expensive and/or in short supply, or, in the case of the alternative pesticides, have limited efficacy as wood preservatives. Consequently, if any one of the major wood preservatives were cancelled, it would be replaced by the remaining registered wood preservative pesticide(s) for the affected uses. However, severe economic impacts to the applicators could result from this cancellation due to the necessary equipment changes that would be required to treat wood with the remaining registered wood preservatives. Moreover, the cancellation of certain uses for which the remaining wood preservatives are not viable substitutes would result in severe economic impacts. Thus, the consumer would pay higher prices for the preservative-treated wood resulting from the severe economic impacts to the applicators and the higher cost of alternative materials.

If creosote were cancelled for all pressure-treatment uses, the first year economic impact to the end-users of treated wood would range from $100.5 million to $106.5 million. For wood which is pressure treated with the inorganic arsenicals, the first year cost impact of cancellation would be an increase ranging from $62 to $68 million; for the pressure treatment uses of penta, the first year cost increases would range from $54 million to $60 million.

The cancellation of penta or sodium penta for non-pressure applications (i.e., sapstain control, millwork and plywood, and particleboard uses) would generally result in the use of alternative chemical preservatives at a substantially higher cost to the applicator and moderate cost increase to the consumers of this treated wood. Moreover, for most use patterns, the alternative chemical preservatives do not provide the same efficacy as penta.

3. Risk/Benefit Analysis:

a. Consideration of Regulatory Options

The Agency has examined the regulatory options which could reduce the risk from exposure to treated wood products. Only a fraction of these options can be implemented under FIFRA since the regulations issued pursuant to FIFRA exempt treated wood products per se from regulation. In the following sections, the Agency will evaluate the modifications which can be implemented under FIFRA and will disuss the regulatory measures which the Agency expects to propose pursuant to the Toxic Substances Control Act (TSCA).

b. Possible Modifications under FIFRA

i. Prohibit Uses Likely to Result in Contamination of Food, Feed, or Potable Water

The general population may inadvertantly be exposed to the wood preservatives through the application of pesticides on wood which is used for vegetable and fruit stakes, mushroom flats and other greenhouse structures, feed lot bins, seed flats, animal bedding, pens, watering or feed troughs, irrigation flumes, food containers or similar wooden articles. The Agency has not determined the actual dietary exposure to wood preservatives resulting from their application to wood products which may contaminate food or water, and has established no tolerances or exemption from tolerances; the U.S. Food and Drug Administration has established no action levels for these pesticides in or on raw agricultural commodities.

To reduce risks to the general public, domestic animals and livestock from the potential wood preservative residues in food or drinking water, the Agency will consider prohibiting the application of these pesticides to wood products which may be used in a manner resulting in direct exposure to domestic animals or livestock, or in the contamination of food, feed, or drinking and irrigation water.

To implement this modification the Agency will require registrants to make an appropriate statement of prohibition on the pesticide labeling. Implementation of this modification will eliminate residues of these pesticides in foodstuffs.

Because the wood preservatives are not currently registered for the uses described above, there should be no cost in implementing this modification.

ii. Limit the Application of Pesticides to Wood Destined for Outdoor and Selected Indoor Uses

The Agency believes that the application of penta, creosote, and the inorganic arsenicals on wood which is destined for interior use or enclosed structures will result in inhalation and dermal exposure to the inhabitants of these dwelling or structures. The Agency has determined that the oncogenic risk to inhabitants in such enclosed areas from the interior uses (e.g., AWWF, plates and sills, and structural framing) of arsenically treated wood range from about 10^{-6} to 10^{-7}. In enclosed areas treated with penta, inhalation exposures of about 8 ug/kg/day may occur as a result of the vaporization of penta. This exposure translates into a fetotoxic MOS of about 380 and the exposure to HxCDD is negligible. Sodium penta, used for sapstain control, is a salt and thus has a very low vapor pressure. Consequently, risks from the use of 0.5% sodium penta for control of sapstain on wood destined for use indoors are not expected to be great. Although the Agency has not quantified the risks resulting from inhalation or dermal exposure to interior wood to which creosote has been applied, the Agency believes there is some degree of risk to anyone contacting creosote-treated wood dermally or breathing fumes in enclosed areas.

To reduce these risks, the Agency will consider limiting the application of creosote, penta, and the inorganic arsenicals to wood that will be destined for exterior and specific interior uses only.

Under this modification the application to wood which would ultimately be used in the interiors of human and animal dwellings will be limited to those posing a minimal risk. To implement this modification the Agency will require the registrant to make appropriate statements of prohibition on the pesticide labeling. Implementation of this modification will reduce risk resulting from the use of the treated wood in interior situations (e.g., paneling, cabinets, interior surfaces of log homes).

In a few situations the Agency believes risks are sufficiently low, in light of the benefits, to warrant continuation of use in interior settings. These uses are: 1) millwork treated with penta which has outdoor surfaces (e.g., doorframes, windows, the outdoor portion of structural laminated beams used as supports, patio frames, and similar wooden items), 2) structures treated with creosote, the inorganic arsenicals or penta which are in contact with the soil in barns, stables, and similar sites, (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards), 3) structures treated with the inorganic arsenicals (i.e., all weather wood foundations, plates and sills, and some structural framing), and 4) wood which has been treated for sapstain with 0.5% or less sodium penta.

iii. Specific Options Selected

Because the risks to the end-users associated with application of the wood preservative pesticides to wood destined for interior uses (except for the exemptions discussed in the previous section) and application of wood preservative pesticides to wood in contact with foodstuffs are unacceptably high, the Agency has not selected Option 1, Continued Registration without changes. The economic impacts of cancellation are sufficiently large that the Agency has not selected the Option 3, Cancellation. The Agency has, therefore, selected Option 2, the Modification of the Terms and Conditions of Registration, as follows:

-- Limit Application of the Pesticide to Wood Destined for Outdoor and Selected Indoor Uses

-- Prohibit Application of the Pesticide to Wood Uses Likely to Result in Contamination of Food, Feed, or Potable Water

The Agency has determined that implementing the modifications described above for creosote, the inorganic arsenicals and penta will reduce the risks to acceptable levels when considered in light of the benefits of these uses, and that the use of these wood preservatives for treatment of wood will not cause unreasonable adverse effects on the environment.

c. Possible Modifications under TSCA

The Agency does not currently regulate end-use products, such as treated wood, where no pesticidal claims are made for the treated item itself under the regulations issued pursuant to FIFRA. However, these wood products can be regulated under the authority of the Toxic Substance Control Act (TSCA), which provides a mechanism for issuing health and safety regulations for chemical substances and materials. The Agency, therefore, proposes to regulate treated wood products under Section 6 of TSCA and to issue regulations to reduce the risks from the use of treated wood in accordance with the rulemaking procedures set forth in TSCA. The action under TSCA will be taken concurrently with the issuance of this PD 2/3, and will utilize information presented in this PD 2/3 in the support document for the proposed TSCA rules. The Agency recognizes that the Consumer Product Safety Commission (CPSC) has some regulatory jurisdiction pertaining to the consumer use of wood treated with pesticides. The CPSC, however, has not issued any pertinent regulations to date. If the CPSC, promulgates regulations covering the wood treated with pesticides, TSCA will be pre-empted to the extent that the CPSC takes sufficient actions to protect against the risks of concern.

In essence the Agency has determined that certain labeling modifications in the use patterns of the treated wood products may be appropriate to provide health and safety protection to the exposed population. These labeling changes are considered below.

1. Distribute Use, Handling, and Disposal Information with Pesticide-Treated Wood

The Agency believes that the majority of the population exposed to or using the pesticide-treated wood is not aware that the wood is treated with a pesticide. To educate and alert the individual involved in construction activities, including the homeowner, to the hazards of pesticide-treated wood, the Agency will consider requiring that procedures for proper use, handling, and disposal be distributed to the end-user of the treated wood.

Section 6(a)(3) of TSCA provides that the Agency can require that the products "be marked with or accompanied by clear and adequate warnings and instructions with respect to its use, distribution in commerce, or disposal or with respect to any combination of these activities." Section 6(a)(2) provides that the Agency can prohibit the processing or distribution in commerce of the product for a particular use. Section 6(a)(5) provides that EPA can prohibit or otherwise regulate any manner or method of commercial use of the product. Section 6(a)(6) provides that the Agency can prohibit or otherwise regulate any manner or method of disposal of the product "by its manufacturer, processor, or by any other person who uses or disposes of it for commercial purposes." Under a combination of these authorities and methods, the Agency could achieve the controls it believes are necessary to protect users of these pesticide-treated wood products and the public at large.

A rule could be promulgated under the above authorities that would require that pesticide-treated wood products to be sold with labels containing use, handling, and disposal information for users and consumers. This approach is consistent with the Agency's concern for regulatory flexibility and would preserve the benefits of wood preservatives while protecting the public from the adverse effects of these chemicals.

The cost of implementing this measure will depend upon the number of single purchases of pesticide-treated wood. It is estimated that labels will cost 3 cents to 31 cents a piece for each transfer of a single lot of wood.

ii. Gloves

As discussed at length in Section V.D.1, dermal exposure can result from contact with wood which has been treated with creosote, penta, or the inorganic arsenicals. To reduce dermal exposure through the hands, the Agency will consider recommending that all persons who come into hand contact with treated wood wear gloves impervious to the wood preservatives (e.g., rubber). This measure would apply to all construction workers, individuals installing fence posts, individuals climbing or working on utility poles, or other occupationally exposed individuals. Although the dermal exposure to creosote-treated wood has not been quantified, wearing gloves is estimated to reduce hand dermal exposure by 99%.

If gloves were worn by workers who handle inorganic arsenical-treated wood, the risk of skin cancer to an individual, which is primarily related to dermal exposure, would be reduced from a range of 7.9×10^{-3} to 3.9×10^{-2} to a range of 8.0×10^{-5} to 4.0×10^{-4}; the tetratogenic/fetotoxic MOS for this activity is increased from approximately 300 to 500 (this estimate includes inhalation exposure and does not include the gastrointestinal exposure which results from sawing inorganic arsenical-treated wood).

Although the Agency does not have sufficient information regarding exposure to workers handling penta-treated wood; as noted earlier, gloves are estimated to reduce hand dermal exposure by 99%.

The annual cost of this modification to a homeowner who is handling pesticide-treated wood is about $5 to $10. If the construction industry provided gloves for its workers ($60 to $312 per worker), the cost of this modification would range from $3.0 million to $15.6 million annually, assuming that gloves are not currently supplied to these workers.

ii. Coveralls, Gloves, and Dust Mask

The Agency has determined that during sawing operations with treated wood, preservative-bearing sawdust tends to become airborne with resultant inhalation, gastrointestinal, and wide spread dermal exposure. The creosote and penta risks have not been quantified; however, during the sawing of inorganic arsenical-treated wood, the total oncogenic risk is estimated to be from a range of 1.6×10^{-1} to 1.3×10^{-1}. The teratogenic/fetotoxic MOS for arsenically treated wood ranges from 106 to 128. To reduce the exposure created from the sawing of pesticide-treated wood, the Agency will consider recommending persons who saw such wood occupationally wear gloves (e.g., rubber) and disposable coveralls (e.g., nitrile or polyethylene; for homeowners, tightly-woven long sleeved cotton coveralls), and a dust mask capable of trapping particulates greater than 5 microns in size.

The Agency has determined that implementation of this modification will reduce total dermal exposure to the preservatives creosote and penta by 80% if gloves and coveralls are worn, and inhalation exposure of particulates by 80% if a dust mask is worn by these workers. Wearing these protective clothing while working with inorganic arsenical-treated wood will reduce the total oncogenic risk from a range of 1.6×10^{-1} to 1.3×10^{-1} to a range of 2.7×10^{-3} to 3.0×10^{-3} and increase the teratogenic/fetotoxic MOS from a range of 106 to 128 to greater than 3,000.

The annual cost of implementing this modification to the construction industry for an employee would be about $20 to $40 for disposable coveralls, $60 to $312 for gloves, and $120 for dust masks. The cost to an individual (e.g., homeowner) would be about $20 for tightly-woven long sleeved cotton coveralls, $5 to $10 for gloves, and $2.50 for dust masks.

iii. Special Disposal of Treated Wood

When creosote-treated wood is burned, various oncogenic or mutagenic compounds may be formed. Wood treated with the inorganic arsenical compounds can produce arsine gas, which is acutely toxic; and arsenic trioxide ash , a teratogen, mutagen and potent oncogen, can be left as a residue. Penta-treated wood, when burned, is believed to produce HxCDD, a potent oncogen and teratogen.

To reduce exposure to the toxic products that may result from burning treated wood, the Agency will consider recommending a prohibition against burning of this wood. Although the Agency believes there is a finite hazard to human health from this practice, this hazard has not been quantified. However, implementation of this modification will eliminate exposure to the potential risks from burning pesticide-treated wood.

Acceptable disposal methods include on-site burial or disposal in accordance with local and state laws. However, if the pesticide-treated wood waste exceeds 1,000 kg per month, per site, disposal must comply with the provisions of the Resource and Recovery Conservation Act (RCRA).

This modification is not expected to have a significant cost in its implementation.

iv. Selection of Regulatory Actions Under TSCA

The Agency will proceed with the development of a labeling regulation under Section 6 of TSCA. The purpose of the regulation will be to advise users of procedures for the proper use, handling, and disposal of treated wood which are recommended to mitigate risks. Some of the selected precautions to be included on the label are listed below:

-- Recommend Gloves (in situations where there is hand dermal contact with preservative-treated wood)

-- Recommend Coveralls, Gloves, and a Dust Mask (for exposed individuals in situations where treated wood is sawn)

-- Recommend Special Disposal of Treated Wood

E. Summary of Proposed Regulatory Actions Under FIFRA

Based upon the determinations set forth above in detail in this Position Document, the Agency is proposing to initiate the following regulatory actions.

1. Cancellation and denial of registration of the spray method of application for pentachlorophenol products which are available for retail sale in concentrations of 5% or less.

CREOSOTE

2. Cancellation and denial of registration of creosote products for wood preservative use on railroad ties, lumber, timber and plywood, pilings, posts, crossarms, and poles unless the registrants modify the labeling of creosote products to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the wood treatment solution (e.g., rubber) in all situations where dermal contact with creosote is possible (e.g., handling treated wood and opening cylinder doors).

ii. All applicators who open treatment cylinder doors must wear gloves and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

iii. Applicators who enter pressure treatment cylinders and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

c. All applicators must leave all protective clothing, work shoes or boots, and equipment at the plant at the end of the day. Worn-out protective clothing must be disposed of in accordance with the instructions for pesticide container disposal.

d. Eating, drinking and smoking is prohibited during the application of creosote products.

e. The application of creosote to wood which is intended for interior use is prohibited, except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in contact with soil in barns, stables and similar sites.

f. Do not apply creosote to wood which will be used in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking and irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

PENTA

3. Cancellation and denial or registration of pentachlorophenol products for wood preservative use on railroad ties, lumber, timber and plywood, pilings, posts, crossarms and poles unless the registrants modify the labeling or products to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the wood preservative solution (e.g., rubber) in all situations where dermal contact with pentachlorophenol is possible (e.g., handling treated wood and opening cylinder doors).

ii. All applicators who open treatment cylinder doors must wear gloves and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

iii. Applicators who enter pressure treatment cylinders and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

c. A closed emptying and a closed mixing system must be used for all prilled (granular) formulations of pentachlorophenol.

d. All applicators must leave all protective clothing, work shoes or boots, and equipment at the plant at the end of the day. Worn-out protective clothing must be disposed of in accordance with the instructions for pesticide container disposal.

e. Eating, drinking and smoking is prohibited during the application of pentachlorophenol products.

f. The application of pentachlorophenol to wood which is intended for interior use is prohibited, except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in contact with the soil in barns, stables and similar sites.

g. Do not apply pentachlorophenol to wood which will be used in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

4. Cancellation and denial of registration of the inorganic arsenical products for wood preservative use on lumber, timber and plywood, pilings, posts, crossarms and poles unless the registrants modify the labeling of the inorganic arsenical products for these uses to include the following statements:

ARSENICALS

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the wood treatment solution (e.g., rubber) in all situations where dermal contact with the inorganic arsenicals is possible (e.g., handling treated wood and opening cylinder doors).

ii. Applicators who enter pressure treatment cylinders and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

iii. Applictors who work outdoors in arsenical wood treatment plants must wear a dust mask capable of trapping 80% of particulates greater than 5 microns in size.

c. A closed emptying and a closed mixing system must be used for all powder formulations of the inorganic arsenicals.

d. All applicators must leave all protective clothing, work shoes or boots, and equipment at the plant at the end of the day. Worn-out protective clothing must be disposed of in accordance with the instructions for pesticide container disposal.

e. Eating, drinking, and smoking is prohibited during the application of inorganic arsenical products.

f. The inorganic arsenical treatment solutions must be filtered prior to use in the treatment cylinders and an additional vacuum step must be used prior to the removal of the treated wood from the treatment cylinders. In addition to these requirements, recommended control technologies to reduce the surface levels of arsenic on treated wood include the use of wood that is free of heavy resins ("clean" wood), the post-treatment rinsing of the treated wood, and the installation of protective sheds or covers over the drying treated wood.

g. The application of the inorganic arsenicals to wood which is intended for interior use is prohibited, except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in contact with the soil in barns, stables and similar sites, all weather wood foundations, sills and plates, and structural framing.

h. Do not apply the inorganic arsenicals to wood which will be used in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

CR + PENTA - GROUNDLINE

5. Cancellation and denial of registration of creosote and pentachlorophenol for wood preservative use for groundline treatment of poles unless the registrants modify the labeling of creosote and pentachlorophenol products for the poles-groundline use to including the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the pentachlorophenol and creosote poles-groundline formulations (e.g., rubber) in all situations where dermal contact is possible.

ii. All applicators must wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing during the application process.

c. All applicators must dispose of worn-out protective clothing in accordance with the instructions for pesticide container disposal.

d. Eating, drinking and smoking is prohibited during the application of creosote and pentachlorophenol products for the poles-groundline use.

HOME & FARM

6. Cancellation and denial of registration of creosote and pentachlorophenol for wood preservative home and farm use unless the registrants modify the labeling of creosote and

pentachlorophenol products for home and farm use to including the following statements:

a. For all creosote products and those pentachlorophenol products containing a pentachlorophenol concentration greater than 5%:

Restricted Use Pesticide For retail sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the pentachlorophenol and creosote treatment solutions (e.g., rubber) in all situations when dermal contact is possible (e.g., handling treated wood).

ii. All non-certified applicators must wear tightly-woven long sleeved cotton coveralls or similar protective clothing during the application process.

iii. All certified applicators who apply creosote and pentachlorophenol by the spray method must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use, and all certified applicators who apply creosote and pentachlorophenol by other application processes (e.g., brush-on) must wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing.

c. All certified applicators applying creosote or pentachlorophenol solutions must dispose of worn-out protective clothing in accordance with the instructions for pesticide container disposal.

d. Eating, smoking, and drinking is prohibited during the application of creosote or pentachlorophenol products.

e. The application of creosote and pentachlorophenol products indoors is prohibited. The application of creosote and pentachlorophenol products to wood intended for interior use is prohibited, except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in conact with the soil in barns, stables and similar sites and millwork (pentachlorophenol only) which has outdoor surfaces (e.g., doorframes, windows and patio frames).

f. Do not use creosote and pentachlorophenol in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

RUSH
ON
As

7. Cancellation and denial of registration of brush-on treatments of the inorganic arsenicals unless the registrants modify the labeling of the inorganic arsenical products to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators must wear gloves impervious to the inorganic arsenical solutions (e.g., rubber) in all situations where dermal contact with the pesticide solution is possible (e.g., handling treated wood).

ii. All applicators must wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing during the application process.

c. Eating, drinking, and smoking during the application of the inorganic arsenical products is prohibited.

d. All applicators applying brush-on inorganic arsenical solutions must dispose of worn-out protective clothing in accordance with the instructions for pesticide container disposal.

e. Do not apply brush-on inorganic arsenical solutions to wood intended for indoor use, except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in contact with the soil in barns, stables and similar sites, all weather wood foundations, sills and plates and structural framing.

f. Do not use the inorganic arsenicals in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

SAPSTAIN

8. Cancellation and denial of registration of sodium pentachlorophenate products for sapstain control unless the registrants modify the labeling of sodium pentachlorophenate products to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators applying sodium pentachlorphenate for sapstain control must wear gloves impervious to sodium pentachlorophenate (e.g., rubber) in all situations where dermal contact with the treatment solutions is possible (e.g., handling treated wood).

ii. All applicators applying sodium pentachlorophenate formulations by the spray method must wear gloves and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

iii. All applicators who enter or clean vats and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

c. A closed emptying and a closed mixing system must be used for all prilled (granular) and powder formulations of sodium pentachlorophenate.

d. All sapstain control applicators must leave all protective clothing, work shoes or boots, and equipment at the plant. Worn-out protective clothing must be disposed of in accordance with the instructions for pesticide container disposal.

e. Eating, drinking and smoking is prohibited during the application of sodium pentachlorophenate for sapstain control.

f. Do not use sodium pentachlorophenate in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

MILLWORK & PLYWOOD

9. Cancellation and denial of registration of the wood preservative use of pentachlorophenol for millwork and plywood unless the registrants modify the labeling of pentachlorophenol for millwork and plywood to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators applying pentachlorophenol to the wood must wear gloves impervious to the wood treatment solutions (e.g., rubber) in all situations where dermal contact with the treatment solutions is possible (e.g., handling treated wood).

ii. All applicators who enter or clean vats, and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots, and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

iii. All applicators who apply pentachlorophenol to millwork and plywood by the spray method must wear gloves and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

c. A closed emptying and a closed mixing system must be used for all prilled (granular) formulations of pentachlorophenol.

d. All applicators who apply pentachlorophenol to millwork and plywood must leave all protective clothing, work shoes or boots, and equipment at the plant at the end of the day. Worn-out protective clothing must be disposed of in accordance with the instructions for pesticide contained disposal.

e. Eating, drinking and smoking is prohibited during the application of pentachlorophenol to millwork and plywood.

f. The application of pentachlorophenol products to wood intended for interior use is prohibited, except for wood which has outdoor surfaces (e.g., doorframes, windows and patio frames).

g. Do not use pentachlorophenol in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

PARTICLE BOARD

10. Cancellation and denial of registration of the wood preservative use of pentachlorophenol on particleboard unless the registrants modify the labeling of pentachlorophenol products for the particleboard use to include the following statements:

a. Restricted Use Pesticide For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicators' certification.

b. Protective Clothing and Equipment

i. All applicators who apply pentachlorophenol to particleboard must wear gloves impervious to pentachlorophenol (e.g., rubber) in all situations where dermal contact with pentachlorophenol is possible (e.g., handling treated particleboard).

ii. All applicators who clean or enter vats, and other related equipment must wear a neoprene-coated cotton or rubberized overall, jacket, gloves and boots and a properly maintained half-mask canister or cartridge respirator designed for pesticide use.

c. A closed emptying and a closed mixing system must be used for all prilled (granular) formulations of pentachlorophenol.

d. Eating, drinking and smoking is prohibited during the application of pentachlorophenol to particleboard.

e. All applicators who apply pentachlorophenol to particleboard must leave all protective clothing, work shoes or boots, and equipment at the plant at the end of the day. Worn-out protective clothing must be disposed of in accordance with the instructions for pestcide container disposal.

f. The application of pentachlorophenol to particleboard intended for any interior use (e.g., kitchen cabinets) is prohibited.

g. Do not apply pentachlorophenol to particleboard which will be used in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking or irrigation water (e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

F. Summary of Projected Regulatory Measures under TSCA

The Agency will also propose regulatory measures for the treated wood under the authority of the Toxic Substances Control Act (TSCA). These TSCA labeling measures would be distributed to the end-users of the treated wood. The Agency recommends that the TSCA labeling include the following statements:

1. All individuals who handle pesticide-treated wood should wear gloves impervious to the wood preservatives (e.g., rubber).

2. Individuals who saw pesticide-treated wood should wear disposable coveralls (e.g., nitrile or polyethylene) or similar protective clothing (for homeowners, tightly-woven long sleeved cotton coveralls are acceptable).

3. Individuals who saw pesticide-treated wood and fabricate structures with treated wood should wear a dust mask capable of trapping 80% of particulates greater than 5 microns in size.

4. Treated wood should not be used indoors except for those support structures (e.g., foundation timbers, pole supports and the bottom six inches of stall skirtboards) which are in contact with the soil in barns, stables and similar sites (all three wood preservatives); all weather wood foundations, sills and plates and structural framing (inorganic arsenicals only); millwork (pentachlorophenol only) which has outdoor sufaces (e.g., doorframes, windows and patio frames); and wood treated for sapstain control with 0.5% sodium pentachlorophenol.

5. Treated wood should not be used in a manner which may result in direct exposure to domestic animals or livestock, or in the contamination of food, feed or drinking and irrigation water

(e.g., food crates, irrigation flumes, vegetable stakes, feed lot bins and watering troughs).

6. Treated wood should not be burned but should be disposed of by methods, such as on-site burial, which are in accordance with local and state laws and/or the Resource Conservation and Recovery Act.

APPENDIX 1 A-C:

REBUTTAL COMMENTS RECEIVED

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LISTING OF REBUTTAL COMMENTS - CREOSOTE

Rebuttal No.	Source	Date of Comment	Date Received
1	Koppers Co. Monroeville, Pa.	7/7/78	11/2/78
1A	Koppers Co., Inc. Denver, Colorado	1/11/79	1/25/79
1B	Koppers Co., Inc. Salem, Va.	1/8/79	1/29/79
1C	Koppers Co., Inc. Guthrie, Ky.	1/12/79	1/29/79
1D	Koppers Co., Inc. Richmond, Va.	1/23/79	1/29/79
1E	Koppers Co., Inc. Kansas City, Mo.	1/26/79	1/30/79
1F	Koppers Co., Inc. Port Newark, N.J.	1/19/79	1/30/79
1G	Koppers Co., Inc. Superior, Wisconsin	UNDATED	1/29/79
1H	Koppers Co., Inc. Tie Plant, Ms.	1/22/79	1/29/79
1J	Koppers Co., Inc. North Little, Ak.	1/8/79	1/29/79
1K	Koppers Co., Inc. Pittsburgh, Pa.	1/25/79	1/29/79
1L	Koppers Co., Inc. Houston, Ts.	1/26/79	1/31/79
1M	Koppers Co., Inc. Florence, S.C.	1/26/79	1/31/79
1N	Koppers Co., Inc. Oroville, Ca.	1/16/79	1/31/79
1P	Koppers Co., Inc. Montgomery, Pa.	1/24/79	1/31/79
1Q	Koppers Co., Inc. Orrville, Oh.	1/23/79	1/31/79
1R	Koppers Co., Inc. Pittsburgh, Pa/ (W/Ltr, Tbl 1&2, Rpts 1973 & 76)	2/9/79	2/12/79

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1S	Manual NFPD (ALL THREE CYS TO GIBBS) KOPPER CO., INC. (NOCY OF MANUAL KEPT PITTSBURGH, PA. W/Encl. Fr. G. G. Kenney)	2/9/79	2/12/79
1T	Koppers Co., Inc. Pittsburgh, Pa.	2/12/79	2/12/79
1U	Koppers Co., Inc. Pittsburgh, Pa. (Review Paper) A. Lawrence	2/9/79	2/12/79
1V	Koppers Co., Inc. Green Spring, West Va.	1/12/79	2/12/79
1W	Koppers Co., Inc. Houston, Ts.	1/30/79	2/14/79
2	Steptoe and Johnson, Atts. Washington, D.C. (Rep. AWPI)	10/23/79	11/2/79
2A	Steptoe and Johnson, Atts. Washington, D.C. (Rep. AWPI)	2/12/79	2/13/79
2B	Steptoe and Johnson, Atts. Washington, D.C. (Rep. AWPI)	4/3/79	4/10/79
2C	Steptoe and Johnson, Atts. Washington, D.C. (Rep. AWPI)		
3	Cooperative Ext. Service Fitzgerald, Ga.	11/3/78	11/13/78
4	Burroughs Wellcome, Co. Reser. Triangle Park, N.C.	11/15.78	11/20/78
5	Woolfoam Corp. New York, N.Y.	11/17/78	11/20/78
6	Department of the Navy Alex., Va.	11/9/78	11/20/78
7	Agro-West, Inc. Wilder, Idaho	11/10/781	11/20/78
8	Link Noe, Wilder Bldg. Ctr. Wilder, Idaho	11/10/78	11/20/78

9	Consolidated Companies Cleveland, Ohio	11/21/78	11/24/8
10	Baird & McGuire, Inc. Holbrook, Mass.	11/16/78	11/27/78
11	Howard Larson Emmett, Idaho	11/13/78	11/29/78
12	I.D. McFarland Co. Sandpoint, Idaho	11/21/78	11/29/78
12A	McFarland Cascade (C.L. Stoddard)	11/9/78	1/18/78
13	Sieben Ranch Co. Helena, Montana	11/20/78	11/21/78
14	Union Oil Co. California	11/29/78	12/5/78
15	Gibson-Homans Co. Cleveland, Oh.	11/30/78	12/5/78
16	Dept. of Transportation and Public Facilities Juneau, Alaska	11/30/78	12/6/78
16A	Dept. of Transportation and Public Facilities Juneau, Alaska	12/12/78	12/21/78
16B	Dept. of Transportation and Public Facilities Juneau, Alaska	12/26/78	1/5/79
17	Johnny L. Crawford Chula, Ga.	11/22/78	12/6/78
18	Potomac Electric Power Co. Washington, D.C.	11/28/78	12/6/78
18A	Potomac Electric Power Co. Washington, D.C.	2/12/78	2/13/78
19	Central Hudson Gas & Electric Corp. Poughkeepsie, N.Y.	11/27/78	12/6/78
19A	Central Hudson Gas & Electric Corp. Poughkeepsie, N.Y.	2/9/78	2/13/79
20	Pacific Power & Light Co. Portland, Oregon	12/1/78	12/6/78

21	Henry J. Ellis New Hampshire	12/4/78	12/8/78
22	Florida Power & Light Co.	11/30/78	12/8/78
23	Public Service Electric & Gas Co. Newark, N.J.	12/1/78	12/6/78
24	Depart. of Highways & Transportation Richmond, Va.	12/1/78	12/11/78
25	Department of Agriculture Atlanta, Ga.	12/5/78	12/11/78
26	Depart. of Transportation Kansas	12/1/78	12/6/78
27	Kennecott Copper Corp. New York, New York	12/4/78	12/13/78
28	Allegheny Power System Greensburg, Pa.	12/7/78	12/13/78
29	Arkansas Power & Light Co. Little Rock, Ak.	12/4/78	12/13/78
30	University of Ill. at Urbana-Champaign Urbana, Ill	12/5/78	12/13/78
31	Dayton Power & Light Dayton, Ohio	12/1/78	12/13/78
32	Depart. of Transportation Dover, Delaware	12/7/78	12/13/78
33	Macgillis & Gibbs Co. Wilwaukee, Wi.	12/8/78	12/13/78
34	Alabama Power Electric System Birmingham, Ala.	12/5/78	12/18/78
35	Depart. of Agriculture Saint Paul, Minnesota	12/12/78	12/18/78
36	Webster Lumber Co. Wayzata, Minn.	12/12/78	12/20/78

37	Depart. of Agriculture Annapolis, Md.	12/13/78	12/20/78
38	Depart. of Interior Washington, D.C.	12/13/78	12/20/78
39	New Orleans Public Service Inc. New Orleans, La.	12/13/78	12/19/78
40	Depart. Agriculture (Kent D. Shelhamer) Commonwealth of Pa.	12/12/78	12/20/78
41	Atlantic Wood Industrties Savannah, Ga.	12/15/78	12/21/78
42	Atchison, Topeka, and Santa Fe Railway Co. Chicago, Ill.	12/13/78	12/21/78
43	Potomac Edison Co. Hagerstown, Md.	12/15/78	12/21/78
44	Idaho Transportation Boise, Idaho	12/14/78	12/21/78
45	Depart. of Agriculture Agana, Guam	12/13/78	12/21/78
46	Atlantic Wood Industries Savannah, Ga.	12/14/78	12/21/78
47	Illinois Depart. of Transportation	12/18/78	12/29/78
48	Colfax Creosoting Co. Pineville, La.	12/15/78	12/29/78
49	Mississippi Power Southern Electric System Gulfport, Ms.	12/21/78	12/29/78
50	Leonard Guss Associates Inc. (J.B. Bonney) Tacoma, Washington	12/20/78	12/29/78
51	R & M Consultants (Dennis Nottingham) Anchorage, Alaska	12/21/78	12/29/78

52	Depart. of Transportation (US Coast Guard) Juneau, Alaska	12/19/78	12/29/78
53	American Seal MFG, Co. Inc. Troy, N.Y.	12/21/78	12/29/78
54	Wm. A. Smith Contracting Co., Inc. Shawnee Mission, Kansas	2/20/78	2/29/78
55	State Depart. of Highways (Col. State Patrol) Denver, Co.	12/14/78	12/29/78
56	Josh Tillinghast Kemah, Texas	12/19/78	12/29/78
57	United Marine Publishing, Inc. Kemah, Texas	12/20/78	12/29/78
58	Vermont Agency of Transportation (Eng. & Constr.) Montpelier, Vermont	12/22/78	12/29/78
59	Tri-County Electric Cooperative Rushford, Minn.	12/22/78	12/29/78
59A	Tri-County Electric Portland, Mich.	4/5/79	4/11/79
60	Otter Tail Power Co. Fergus Falls, Minn.	12/22/78	12/29/78
61	Southern Wood Piedmont Co. Spartanburg, S.C.	12/19/78	1/2/79
61A	Southern Wood Piedmont Co. Spartanburg, S.C.	2/6/79	2/13/79
62	Ohio Depat. of Agriculture Columbus, Ohio	12/22/78	1/3/79
63	Dept. of the Army (Engineering Res. Ctr.) Fort Belvoir, Va.	12/22/78	1/3/79

64	Public Service Co. of New Hampshire Manchester, N.H.	12/21/78	1/4/79
65	Coopers Creek Chemical Corp. West Conshohocken, Pa.	12/27/78	1/5/79
66	Indiana State Highway Commission Indianapolis, Indiana	12/27/78	1/5/79
67	California Dept. of Transportation Sacramento, California	12/28/78	1/5/79
68	Ohio Dept. of Transportation Columbus, Ohio	12/26/78	1/5/79
69	Dept. of Transportation FAA Washington, D.C.	1/3/79	1/5/79
70	Maine Dept. of Transportation Augusta, Maine	12/26/78	1/5/79
71	Conroe Creosoting Co. Conroe, Texas (Henry E. Steitz)	12/28/78	1/5/79
71A	Conroe Creosoting Co. Conroe, Texas (Richard Parker)	12/29/78	1/5/79
71B	Conroe Creosoting Co. Conroe, Texas (J.A. Ramey)	12/30/78	1/10/79
71C	Conroe Creosoting Co. Conroe, Texas (C. Hawthorne)	1/5/79	1/10/79
71D	Conroe Creosoting Co Conroe, Texas (Marie Henry)	12/30/78	1/10/79
71E	Conroe Creosoting Conroe, Texas (George Brodnax)	12/30/781	1/10/79
71F	Conroe Creosoting Conroe , Texas (W.E. Kolbe)	12/30/78	1/10/79

71G	Conroe Creosoting Conroe, Texas (E. Weisinger)	12/30/78	1/10/79
71H	Conroe Creosoting Conroe, Texas (J. Lumpkin)	12/30/78	1/10/79
71J	Conroe Creosoting Conroe, Texas (Charline Muller)	12/30/78	1/10/79
71K	Conroe, Creosoting Conroe, Texas (V.L. Andrews)	12/30/78	1/11/79
72	Marine, Inc. General Contractor Kemah, Tx.	12/15/78	1/5/79
73	Darvin & Maurine Taylor Cut 'N Shoot, Tx.	12/19/78	1/5/79
74	Consumers Power Co. Jackson, Mich.	12/29/71	1/5/79
75	Chicago North Western Transportation Co.	12/21/78	1/5/78
76	H. M. Monty Hawthorne Conroe, Tx.	UNDATED	1/10/79
77	Dept. of Transportation & Development (LA) Baton Rouge, La.	12/28/78	1/10/79
78	James Huggins & Sons Inc. Malden, Ma.	1/5/79	1/10/79
79	G. S. McClellan Conroe, Texas	12/30/78	1/10/79
80	Jery Schaller Conroe, Texas	12/30/78	1/10/79
81	Lennice Sloan (Timber Distributioin) Willis, Tx.	12/30/78	1/10/79
82	City Public Service of San Antonio San Antonio, Texas	12/29/78	1/10/79
83	Ecological & Specialty Products, Inc.	12/27/78	1/10/79

84	Fla. Dept. of Agriculture & Consumer Service Tallahassee, Fla.	12/22/78	1/10/79
85	N.C. State University Raleigh, N.C.	12/15/78	12/28/78
86	Dept. of Transportation (Commonwealth of Pa.) Harrisburg, Pa.	1/2/79	1/10/79
87	Utah Dept. of Transportation Salt Lake City, Utah	1/2/79	1/9/79
88	L & M Lumber Co., Inc. (McMillin) Willis, Tx.	12/30/78	1/12/79
89	Elco Manufacturing Co., Inc. Pittsburgh, Pa.	12/20/78	12/28/78
89A	Elco Manufacturing Co. Inc. Sharpsburg, Ps.	1/16/79	1/29/79
90	H. Harwood Loos Bristol, Pa.	12/22/78	12/29/78
91	Monogahela Power Co. Fairmont, West Va.	1/12/79	1/17/79
92	Stephen F. Austin State University Nacogdoches, Texas	1/11/79	1/17/79
92A	Stephen F. Austin State University Nacogdoches, Texas	1/12/79	1/25/79
93	Philadelphia Electric Co. Philadelphia, Pa.	1/11/79	1/18/79
94	Pacific Gas and Electric San Francisco, Ca.	1/12/79	1/25/79
95	Oregon State University (Prof. Graham)(W/Attach.) Corvallis, Oregon	1/16/79	1/25/79
96	Farmers Union Central Exchange, Inc. St. Paul, Mn.	1/11/78	1/25/78

97	Lake States Wood Preserving, Inc. Munising, Michigan	1/16/79	1/25/79
98	Rexham Corporation Matthews, N.C.	1/10/79	1/25/79
99	Yakima County Farm Bureau Yakima, Washington	1/17/79	1/24/79
100	James Koss Paint and Wallpaper Inc.	1/19/79	1/24/79
101	St. Germain Bros. Inc,. Duluth, Mn.	UNDATED	1/24/79
102	Fleet Distributing Supply Wadena, Mn.	1/79	1/24/79
103	Ham Paint Supply Minnepolis, Mn.	1/19/79	1/24/79
104	Fleet Distributing Supply Co. Little Falls, Mn.	1/19/79	1/24/79
105	Haberman Supplies Owatonna, Mn.	1/19/79	1/24/79
106	Indiana Farm Bureau Cooperative Assn., Inc. Indianapolis, Indiana	1/15/79	1/25/79
107	Kenneth Strube Rochester, Mn.	1/19/79	1/26/79
108	G.F. Nemitzs' Sons Hutchinson, Mn.	1/19/79	1/26/79
109	Peck, C.K. Lexington, Oregon	1/7/79	1/24/79
110	Julian Orhrymowych	1/23/79	1/30/79
111	Burke-Parsons-Bowlby Corporation	1/17/79	1/29/79
112	St. Regis Paper Company St. Louis Park, Mn.	1/16/79	1/29/79
113	Ohio State Tie And Timber, Inc., Columbus, Ohio	1/19/79	1/29/79
114	VEPCO Richmond, Va.	1/18/79	1/31/79

114A	VEPCO Richmond, Va.	7/12/79	8/10/79
115	Voided		
116	Jan J. Don Grandview, Washington	1/22/79	2/7/79
117	Kopper Company Inc., Carbondale, Ill.	1/26/79	2/7/79
117A	Kopper Company Inc., Gales, Ill.	1/26/79	2/7/79
118	David Hibbard Post Falls, Idaho	1/24/79	2/1/79
119	Koppers Company Inc., Nasuha, N.H. (John L. Peterson)	1/29/79	2/2/79
119A	Koppers Company Inc., Nashua, N.H. (Charles Fereday)	1/29/79	2/2/79
120	J.N. Kressbach Gillette, N.C.	1/30/79	2/7/79
121	Harris Teeder Super Markets Inc. Charlotte, N.C.	1/30/79	2/6/79
122	H. J. Haemmerlie Gainesville, Fla.	1/29/79	2/1/79
123	Dept. of Public Instruction Raleigh, N.C.	1/23/79	2/1/79
124	Martin Marietta Chemicals Charlotte, N.C.	1/26/79	2/1/79
125	F. A. Bartlett Tree Expert Co. Stamford, Ct.	1/24/79	2/1/79
126	Shoppers Supply Smidt Distr. Inc. Spencer, Iowa	1/25/79	2/1/79
127	Andren's Inc. Duluth, Mn.	1/24/79	2/1/79
128	Robert C. Snyder Center Lovell, Maine	1/29/79	2/2/79

129	W.J. Smith Wood Preserving Co. Denison, Texas	1/26/79	2/5/79
130	Edison Electric Institute Washington, D.C.	1/31/79	2/2/79
131	W.T. Harris Charlotte, N.C.	1/27/79	2/5/79
132	Richard H. Danielson Atlanta, Ga.	1/24/79	2/1/79
133	Southern California Edison Co. Rosemead, California	1/29/79	2/7/79
134	Texas Power & Light Co. Dallas, Texas	1/26/79	2/7/79
135	Ace Hardware Corporation Oak Brook, Illinois	1/29/79	2/8/79
136	Charlie Reed Rosalia, Washington	1/26/79	2/8/79
137	B.H. LeSueur Gainesville, Florida	1/30/79	2/8/79
138	Export Leaf Tobacco Co. Richmond, Virginia	2/2/79	2/9/79
139	J.A. Jones Construction Co. Charlotte, N.C.	1/29/79	2/9/79
140	R.O. Watson Wilmington, Delaware	2/1/79	2/9/79
141	Wood Preservers, Inc. Warsaw, Va.	2/1/79	2/9/79
142	Jennison-Wright Corp. Toledo, Ohio	2/2/79	2/9/79
143	West European Tar Industry London, England	2/5/79	2/12/79
144	Texas Forest Service Lufkin, Texas	2/5/79	2/12/79
145	Clevland Elecetric Illuminating Co. Cleveland, Ohio	1/23/79	2/1/79
146	Dallas Power & Light Co. Dallas, Texas	2/6/79	2/12/79

146A	Dallas Power & Light Co. Dallas, Texas	8/3/79	8/10/79
147	American Electric Power Service Corporation New York, N.Y.	2/7/79	2/12/79
148	Public Service Co. of N.M., Albuquerque, N.M.	2/9/79	2/12/79
149	Allied Chemical Morristown, N.J.	2/9/79	2/12/79
150	Department of Transportation (Federal RR Admin.) Washington, D.C.	2/12/79	2/13/79
151	Assn. of American Railroads (Law Dept.) Washington, D.C.	2/12/79	2/13/79
152	Idaho Power Co. Boise, Idaho	2/9/79	2/13/79
153	Public Service Co. of Oklahoma Tulsa, Oklahoma	2/8/79	2/13/79
154	Carolina Power & Light Co. Raleigh, N.C.	2/8/79	2/13/79
155	Texas Forestry Association Lufkin, Texas	2/7/79	2/13/79
156	Portland General Electric Co. Portland, Oregon	2/8/79	2/13/79
157	Middle South Service Inc. New Oreleans, La.	2/8/79	2/13/79
158	Central Vermont Public Service Corporation Rutland, Vermont	2/9/79	2/13/79
159	Texas Electric Service Co. Fort Worth, Texas	2/5/79	2/13/79
160	Upper Peninsula Power Co. Houghton, Michigan	2/8/79	2/13/79
161	Duke Power Co. (Legal Dept.) Charlotte. N.C.	2/9/79	2/13/79

161A	Duke Power Co. (Legal Dept.) Charlotte, N.C.	3/16/79	3/20/79
162	Union Electric Co. St. Louis, Mo.	2/8/79	2/13/79
163	Mark Johnson, Idaho	1/21/79	2/13/79
164	M.L. Dale, Wayne Floch Pummer, Idaho	UNDATED	2/13/79
165	Alfred L. Borchert, Nampa, Idaho	UNDATED	2/13/79
166	M.T. Laurmin, Casper, Wyoming	UNDATED	2/13/79
167	Arizona Public Service Co. Phoenix, Arizona	2/6/79	2/13/79
168	Georgia Power Co. (Southern Electric System) Atlanta, Georgia	2/7/79	2/13/79
168A	Georgia Power Co. Atlanta, Georgia	8/14/79	8/20/79
169	Northeast Utilities Hartford, Connecticut	2/7/79	2/13/79
170	N.Y. Power Pool Schenectady, N.Y.	2/8/79	2/14/79
171	New England Power Service Westborough, Mass.	2/9/79	2/14/79
172	U.S. Dept. of Commerce (Industry & Trade Admin.) Washington, D.C.	2/14/79	2/15/79
173	PA Electric Co. Johnstown, Pa.	2/12/79	2/15/79
174	Nixon, Hargrave, Devans, & Doyle (Rep: Rochester Gas & Electric) Rochester, N.Y.	2/12/79	2/15/79
175	Indianapolis Power & Light Co. Indianapolis, Indiana	2/9/79	2/15/79
176	Ill. Power Company Decatur, Ill.	2/9/79	2/15/79

176A	Illinois Power Co. Decatur, Ill.	3/14/79	3/20/79
177	Tampa Elec. Co. Tampa, Fla.	2/9/79	2/15/79
178	Jersey Central Power & Light Co. Morristown, N.J.	2/6/79	2/15/79
179	Central & South West Services, Inc. Dallas, Texas	2/8/79	2/15/79
180	New York State Elec. & Gas Corporation Binghamton, N.Y.	2/8/79	2/15/79
181	Pa. Power & Light Co. Allentown, Pa.	2/9/79	2/15/79
182	Canal Electric Co. Sandwich, Ma.	2/9/79	2/15/79
183	Cambridge Electric Light Co. Cambridge, Ma.	2/9/79	2/15/79
184	Iowa Electric Light & Power Co. Cedar Rapids, Iowa	2/5/79	2/15/79
185	New Bedford Gas & Edison Light Co. New Bedford, Ma.	2/9/79	2/15/79
186	Southern States Cooperative Richmond, Va.	2/5/79	2/15/79
187	Niagara Mohawk Power Corporation Stracuse, N.Y.	2/6/79	2/15/79
188	Minnesota Power & Light Co. Duluth, Mn.	2/8/79	2/15/79
188A	Minnesota Power & Light Co. Duluth, Mn.	2/28/79	3/7/79
189	Boston Edison Co. Boston, Ma.	2/5/79	2/15/79
190	Department of Transportation Raleigh, N.C.	2/12/79	2/15/79

191	Joint Industry Coal Tar Committee Jersey City, N.J.	2/15/79	2/16/79
192	Kerr-McGee Chemical Corporation Oklahoma City, Oklahoma	2/9/79	2/16/79
193	Samuel Cabot Inc. Manufacturers (2nd mailing incl. ltr fr Herrick & Smith) Boston, Mass.	2nd ltr 2/15/79 2/6/79	2nd ltr 2/23/79 2/16/79
194	Kansas Power & Light Co. Topeka, Ks.	2/12/79	2/22/79
195	Iowa-Illinois Gas & Electric Co. Davenport, Iowa	2/8/79	2/22/79
196	University of California (Coop. Extension) Davis, California	2/13/79	2/22/79
197	Lincoln Electric Cooperative Inc. Davenport, Washington	2/12/79	2/22/79
198	Ron Frei Grangeville, Idaho	UNDATED	2/22/79
199	Long Island Lighting Co. Hicksville, N.Y.	2/13/79	2/22/79
200	Public Service Co. of Colorado Denver, Colorado	2/9/79	2/23/79
201	Langley and McDonald Professional Corp. Va. Beach, Va.	2/9/79	2/23/79
202	McCormick & Baxter Creosoting Co. Portland, Oregon	2/8/79	2/23/79
203	National Solvent Corp. Medina, Ohio	2/11/79	2/23/79
204	Detroit Edison Elec. Co. Detroit, Michigan	2/5/79	2/23/79
205	Gulf States Utilities Co. Beaumont, Texas	2/9/79	2/23/79

206	Atlantic Electric Atlantic City, N.J.	2/8/79	2/23/79
207	West Penn Power Co. Cabin Hill, Greensburg, Pa.	2/9/79	2/23/79
208	Childscapes, Inc. Atlanta, Ga.	2/12/79	2/23/79
209	Wisconsin Public Service Corporation Green Bay, Wi.	2/12/79	2/23/79
210	Iowa Public Service Co. Souix City, Iowa	2/12/79	2/23/79
211	Cincinnati Gas & Electric Company Cincinnati, Ohio	2/12/79	2/23/79
212	Langdale Company Valdosta, Ga.	2/7/79	2/26/79
213	Ohio Edison Co. Akron, Ohio (see 213A)	2/5/79	2/27/79
214	Baltimore Gas & Electric Co. Baltimore, Md.	2/8/79	2/27/79
215	C.H. Abrams Lilburn, Ga.	2/12/79	2/28/79
216	Koppers Company Inc. Salisbury, Md.	2/12/79	2/28/79
217	Department of Transportation (Trans Bldg.) Salem, Oregon	2/16/79	2/28/79
218	Scharf Family, Amity, Oregon	1/6/79	2/28/79
219	Catawba Timber Company Catawba, South Carolina	2/22/79	3/1/79
220	Missouri Power & Light Co. Jefferson City, Missouri	2/21/79	3/1/79
221	Kaiser Agricultural Chemicals Savannah, Ga.	2/22/79	3/5/79
222	Tucson Gas & Electric Co. Tuscon, Arizona	3/5/79	3/8/79

223	Singing River Electric Power Association Lucedale, Ms.	2/28/79	3/8/79
224	Liz Vanleeuwen Halsey, Oregon	2/12/79	3/7/79
225	Bowater Carolina Corp. Catawba, S.C.	2/23/79	3/7/79
226	Vertac, Inc Memphis, Tn.	2/9/79	3/7/79
227	Public Utility District No. 1 of Klickitat City Goldendale, Washington	3/9/79	3/13/79
228	Port Authority of New York & New Jersey New York, N.Y.	3/14/79	3/21/79
229	Savannah Electric and Power Company Savannah, Ga.	UNDATED	3/22/79
230	Columbus and Southern Ohio Electric Co. Columbus, Ohio	3/19/79	3/30/79
231	Poudre Valley Rural Electric Association Fort Collins, Colorado	3/23/79	3/30/79
232	Oregon Wheat Growers League T.W. Thompson (Oregon)	1/23/79	4/9/79
233	REMC, Boone County Rural Electric Corp. Lebanon, Indiana	4/3/79	4/10/79
234	Delaware County Electric Coop. Delhi, N.Y.	UNDATED	4/10/79
235	Harkers Island Electric Corporation Harkers Island, N.C.	4/3/79	4/10/79
236	Roanoke Electric Corp. Rich Square, N.C.	4/3/79	4/10/79
237	Flint Hills Rural Elec. Coop. Assoc. Inc. Council Grove, Kansas	UNDATED	4/10/79

237A	Flint Hills Rural Elec. Coop. Assoc. Inc. Council Grove, Kansas	4/9/79	4/17/79
238	Ohio State University (Forestry Division) Columbus, Ohio	3/26/79	4/10/79
239	Farmers Electric Coop. Inc. Greenfield, Iowa	UNDATED	4/10/79
240	Continental Divide Electric Coop. Inc. Grants, New Mexico	4/3/79	4/10/79
241	McLennan County Electric Coop. Inc. McGregor, Texas	4/2/79	4/10/79
242	Taylor Electric Coop. Inc. Merkel, Texas	UNDATED	4/11/79
243	Springer Electric Coop. Inc. Springer, New Mexico	4/4/79	4/11/79
244	East Ms. Electric Power Association Meridian, Ms.	4/4/79	4/11/79
245	Grundy Electric Coop., Inc. Trenton, Mo.	4/5/79	4/11/79
246	Tri-County Electric Co-Op Inc. Azle, Texas	4/6/79	4/11/79
247	Rio Grande Electric Coop. Inc. Brackettville, Texas	4/5/79	4/11/79
248	Snohomish County Public Utility District No. 1 Everett, Washington	4/3/79	4/11/79
249	Admas Electric Coop. Inc. Gettysburg, Pa.	4/5/79	4/11/79
250	Nebraska Electric Generation & Transmission Coop., Inc. Columbus, Nebraska	4/4/79	4/11/79
251	Southern Pine Electric Coop. Brewton, Alabama	4/9/79	4/13/79

252	Midstate Electric Coop., Inc. LaPine, Oregon	4/4/79	4/13/79
253	Guthrie County Rural Electric Coop., Gunthrie Center, Iowa	4/6/79	4/13/79
254	Norris Public Power District Beatrice, Nebraska	UNDATED	4/13/79
255	Twin Valleys Public Power District Cambridge, Nebraska	4/6/79	4/13/79
256	Southeast Electric Coop., Inc. Ekalaka, Montana	4/5/79	4/13/79
257	Halifax Electric Membership Corp., Enfield, N.C.	4/6/79	4/13/79
258	Logan County Co-Op Power and Light Assoc., Inc. Bellefontaine, Ohio	4/4/79	4/13/79
259	K.C. Electric Assoc. Hugo, Colorado	4/4/79	4/13/79
260	Tallapoosa River Electric Coop., LaFayette, Alabama	4/5/79	4/13/79
261	Harney Electric Coop., Inc. Burns, Oregon	4/6/79	4/13/79
262	Johnson County Electric Coop., Cleburne, Texas	4/6/79	4/13/79
263	Kiamichi Electric Coop., Inc. Wilburton, Oklahoma	4/6/79	4/13/79
264	Tri-County Electric Membership Corp., Goldsboro, N.C.	4/5/79	4/13/79
265	Dixie Electric Membership Corporation Baton Rouge, La.	4/9/79	4/13/79
266	Midwest Electric Inc. St. Marys, Ohio	4/10/79	4/13/79

267	Lincoln Electric Cooperative, Inc. Eureka, Montana	4/9/79	4/13/79
268	Northeast Missouri Electric Power Corp. Palmyra, Mo.	4/4/79	4/13/79
269	RSR Electric Coop., Inc. Milnor, N.D.	4/9/79	4/17/79
270	The Victory Electric Coop., Assoc., Inc. Dodge City, Kansas	4/9/79	4/17/79
271	United Electric Corp., Inc. Dubois, Pa.	4/10/79	4/17/79
272	Howard Electric Coop., Fayette, Mo.	4/9/79	4/17/79
273	Okefenoke Rural Electric Membership Corp., Nahunta, Ga.	4/9/79	4/17/79
274	Kandiyohi Coop., Elec. Power Association Wilimar, Mn.	4/9/79	4/17/79
275	EMC Lumbee River Electric Membership Corp., Red Springs, N.C.	4/4/79	4/17/79
276	Planters Electric Membership Corp., Millen, Ga.	4/5/79	4/17/79
277	Golden Valley Electric Association, Inc. Fairbanks, Alaska	4/5/79	4/17/79
278	Re Sand Mountain Elec. Coop. Rainesville, Ala.	4/9/79	4/17/79
279	Lake Region Electric Coop., Inc. Hulbert, Ok.	4/9/79	4/17/79
280	Haywood Electric Membership Corp., Waynesville, N.C.	4/11/79	4/17/79
281	Grand Electric Coop., Inc. Bison, S.D.	4/9/79	4/17/79

282	Alger Delta Coop., Elec. Assoc. (No Atch) Gladstone, Mi.	4/12/79	4/18/79
283	C & W Rural Elec. Coop. Assoc. Clay Center, Kansas	4/13/79	4/18/79
284	Slope Elec. Coop., Inc. New England, N.D.	4/12/79	4/18/79
285	Moreau-Grand Electric Coop., Inc. Timber Lake, S.D.	4/3/79	4/20/79
286	Valley Electric Membership Corp., Natchitoches, La.	UNDATED	4/20/79
287	Re York County Rural Public Power District York, Nebraska	4/13/79	4/20/79
288	EMC Carroll (Electric Membership Corp.) Carrolton, Ga.	4/12/79	4/20/79
289	Mitchell Electric Membership Corp., Camilla, Ga.	4/11/79	4/20/79
290	Flathead Electric Coop., Inc. Power & Light Kalispell, Montana	4/12/79	4/20/79
291	East Central Electric Assoc. Braham, Minnesota	4/11/79	4/20/79
292	North-Central Electric Coop., Inc. Attica, Ohio	4/12/79	4/20/79
293	Shenadoah Valley Electric Coop., Inc. Dayton, Va.	4/11/79	4/20/79
294	Sac Osage Electric Coop. El Dorado Springs, Mo.	4/9/79	4/20/79
295	Cavalier Rural Electric Coop., Inc. Langdon, N.D.	4/11/79	4/20/79
296	Wheatland Rural Electric Association Wheatland, Wyoming	4/11/79	4/20/79

297	Beauregard Electric Co-op Inc. De Ridder, La.	4/6/79	4/20/79
298	Beartooth Electric Co-op Inc. Red Lodge, Montana	4/9/79	4/20/79
299	Pickwick Electric Coop., Selmer, Tennessee	4/12/79	4/20/79
300	Pea River Electric Coop., Ozark, Alabama	4/18/79	4/24/79
301	Peace River Electric Cooperative, Inc. Wauchula, Fla.	4/17/79	4/24/79
302	Plumas-Sierra Rural Electric Cooperative, Inc. Portola, California	4/17/79	4/24/79
303	Covington Electric Coop., Inc. Andalusia, Alabama	4/18/79	4/24/79
304	Southwest Texas Electric Coop., Inc. Eldorado, Texas	4/16/79	4/24/79
305	Polk County Rural Public Power District Stromsburg, Nebraska	4/9/79	4/24/79
306	EMC Blue Ridge Electric Membership Corp., Lenoir, N.C.	4/23/79	4/26/79
307	Kamo Electric Cooperative Inc. Vinita, Oklahoma	4/20/79	4/26/79
308	Bruce Hunt Salem, Oregon	3/10/79	4/30/79
309	Verendyre Electric Cooperative, Inc. Velva, N.D.	4/23/79	4/30/79
310	Wise Electric Cooperative, Inc. Decatur, Texas	4/18/79	4/30/79
311	Cumberland Electric Membership Corp., Clarksville, Tn.	4/20/79	4/30/79

312	Cullman Electric Cooperative Cullman, Alabama	4/17/79	4/30/79
313	Jackson County Rural Elec. Membership Corp., Brownstown, Indiana	4/18/79	4/30/79
314	Corn Belt Power Cooperative Humboldt, Iowa	4/16/79	4/30/79
315	Sumpter Electric Membership Corp., Americus, Ga.	4/19/79	4/30/79
316	Lower Valley Power & Light, Inc. Afton, Wyoming	4/19/79	4/30/79
317	Shelby Rural Electric Cooperative Corp., Shelbyville, Ky.	4/20/79	4/30/79
318	Harrison County Rural Electric Membership Corp., Corydon, Indiana	4/20/79	5/1/79
319	Edgecombe-Martin County Electric Membership Corp., Tarboro, N.C.	4/26/79	5/4/79
320	Kosciusko County Rural Electric Membership Corp., Warsaw, Indiana	4/30/79	5/4/79
321	Jackson Electric Membership Corp., Jefferson, Ga.	4/27/79	5/4/79
322	Fairfield Electric Cooperative, Inc. Winnsboro, S.C.	4/27/79	5/4/79
323	Barc Electric Cooperative Millboro, Va.	4/30/79	5/4/79
324	Habersham Electric Membership Corp., Clarksville, Ga.	4/25/79	5/4/79
325	Western Illinois Electrical Coop., Carthage, Illinois	4/24/79	5/4/79
326	Hickman-Fulton Counties Electric Coop. Corp., Hickman, Ky.	4/30/79	5/4/79

327	Meriwether Lewis Electric Cooperatie Centerville, Tn.	4/27/79	5/8/79
328	Washington State University (Coop. Ext. Service) Pullman, Washington	5/3/79	5/9/79
329	American Institute of Timber Construction Englewood, Colorado	5/2/79	5/9/79
330	Southern Maryland Electric Coop., Inc. Hughesville, Md.	5/3/79	5/9/79
331	Oliver B. Wilbers Umpqua, Or.	4/7/79	5/17/79
332	Dairyland Power Coop. La Crosse, Wisconsin	5/10/79	5/17/79
333	Oliver-Mercer Elec. Coop. Hazen, N.D.	5/9/79	5/17/79
334	Eastern Iowa Light & Power Corp., Wilton, Iowa	5/9/79	5/21/79
335	Cookson Hills Elect. Coop. Inc. Stigler, Ok.	4/26/79	5/2/79
336	Coos Curry Elect. Coop., Inc. Coquille, Oregon	5/9/79	5/23/79
337	Iversek Research Int'l. London, England	5/29/79	6/6/79
338	Green River Elec. Corp., Owensboro, Ky.	6/5/79	6/14/79
339	Concordia Elec. Coop. Inc. Ferriday, La.	6/11/79	6/22/79
340	Alabama Power Co., Birmingham, Ala.	6/15/79	6/22/79
341	Electric Power Board Chattanooga, Tn.	6/15/79	6/28/79
342	U.S. Dept. of Agriculture Forest Serv, Ashville, N.C.	6/15/79	6/28/79

343	Ms. Power Co. Gulfport, Ms.	6/20/79	6/28/79
344	Public Utility Dist. No.1 Okanogan, Wa.	7/2/79	7/9/79
345	Iowa Southern Utility Co. Centerville, Iowa	7/3/79	7/9/79
346	OASD, DOD (G. Marienthal) Washington, D.C.	6/27/79	7/12/79
347	Memphis Light, Gas & Water Div., Memphis, Tn.	7/11/79	7/19/79
348	Lincoln Elec. Coop. Inc. Eureka, Montana	6/25/79	7/19/79
349	Montana State University Bozeman, Montana	7/16/79	8/2/79
350	Gulf States Util. Co. Beaumont, Tx.	8/2/79	8/10/79
351	McKenze Elec. Co-op, Inc. Waterford, N.D.	7/13/79	8/10/79
352	Cleveland Utilities Cleveland Tn.	7/6/79	8/10/79
353	Interstate Power Co. Dubuque, Iowa	8/2/79	8/16/79
354	TR International London, England	7/26/79	8/16/79
355	National Rural Elec. Coop., Washington, D.C.	8/22/79	8/22/79
356	American Wood Preservers Institute Pittsburgh, PA	2/28/80	2/28/80

LISTING OF REBUTTAL COMMENTS - INORGANIC ARSENICALS

Rebuttal No.	Source	Date of Comment	Date Received
1	Penwalt Corporation King of Prussia, PA.	10/25/78	11/20/78
1A	Penwalt Corporation (See #1) (2 Vols) Philadelphia, PA.	2/12/79	2/12/79
2	Steptoe & Johnson (Rep. AWPI) Washington, D.C.	10/23/78	11/20/78
2A	Steptoe & Johnson (Rep AWPI) Washington, D.C.	2/14/79	2/15/79
2B	Steptoe & Johnson Washington, D.C.	4/20/79	4/26/79
2C	Steptoe & Johnson Washington, D.C.	1/28/80	1/31/80
3	Society of American Wood Preservers, Inc.	9/12/78	11/21/78
4	University of Ga. Coll. Fitgerald, GA.	11/3/78	11/20/78
5	Department of Navy Alexandria, VA.	11/17/78	11/20/78
6	Petit Paint Co., Inc. Borough of Rockaway, N.J.	11/9/78	11/20/78
7	Agro-west, Inc. Wilder, Idaho	11/10/79	11/20/78
8	Wilder Building Center - Wilder, Idaho	11/10/78	11/20/78
9	Oregon State University Corvallis, OR.	11/14/78	11/20/78
10	Kiry Silsbee, TX.	11/14/78	11/27/78
11	National Cotton Council Memphis, TN.	12/16/78	11/27/78
12	Howard Larson Emmett, Idaho	11/13/78	11/27/78

13	Donald Wallin	UNDATED	11/28/78
14	Isedor Wallin	UNDATED	11/28/78
15	Sanpoint, Idaho L.D. McFarland Co.	11/21/78	11/27/78
16	Chemicals, Inc. New Jersey	11/30/78	12/06/78
16A	Chemicals, Inc. Sewaren, N.J.	01/29/78	2/26/78
17	Chevron Chemical Co. Richmond, CA.	11/21/78	12/05/78
18	Florida Power & Light Co. Miama, FLA.	11/30/78	12/08/78
19	Johnny L. Crawford Chula, Georgia	11/22/78	12/06/78
20	Potomac Electric Power Co. Washington, D.C.	2/13/79	2/13/79
20A	Potomac Electric Power Co. washington, D.C.	2/13/79	2/13/79
21	Central Hudson Gas & Electric Corp. Poughkeepsie, N.Y.	1127/78	12/06/78
21A	Central Hudson Gas & Electric Corp. Poughkeepsie, N.Y.	2/9/78	2/13/78
22	Pacific Power & Light Co. Portland, OR.	12/1/78	12/6/78
23	R.J. Pokorny Westport, CONN.		
24	Senoret Chemical Co. Kirkwood, Missouri	12/1/78	12/8/78
25	Department of Agriculture	12/5/78	12/11/78
26	Henry J. Ellis Mancvhester, New Hamshire	12/4/78	12/8/78
27	Public Service Electric & Gas Co. Newark, N.J.	12/1/78	12/6/78

28	Dept. of Highways & Transportation Richmond, VA.	12/1/78	12/11/78
29	Jones Products Co., Inc Middleton, WI.	12/1/78	12/13/78
30	United Building Supply, Inc. Anchorage, Alaska	12/8/78	12/13/78
31	Department of Transp. Dover, Delaware	12/7/78	12/13/78
32	Dayton Power and Light Dayuton, Ohio	12/1/78	12/13/78
33	University of Ill. Urbana, Illinois	12/5/78	12/13/78
34	Arkansas Power & Light Co. Litle Rock, Arkansas	12/4/78	12/13/78
35	Allegheny Power System Greensburg, PA.	12/7/78	12/13/78
36	Alabama Power Electric System Birmingham, ALA.	12/5/78	12/18/78
37	Department of Agriculture Saint Paul, MINN.	12/12/78	12/18/78
38	West Elizabeth Lumber Co. West Elizabeth, PA.	12/13/78	12/18/78
39	J. H. Baxter & Co. San Mateo, California	12/14/78	12/20/78
40	Department of Interior Washington, D.C.	12/13/78	12/20/78
41	Dept. of Agriculture (K.D. Shelhamer) Commonwealth of PA.	12/12/78	12/18/78
42	Dept. of Agriculture Annapolis, MD.	12/13/78	12/20/78
43	Dept. of Transp. Agana, Guam	12/13/78	12/21/78
44	Dept. of Transp. State of Idaho	12/14/78	12/21/78
45	Potomac Edison Co. Hagerstown, MD.	12/15/78	12/21/78

46	Atchinson, Topeka, & Santa Fe RR Co. Chicago, ILL.	12/13/78	12/21/78
47	Atlantic Wood Industries (A.G. Labrot) Savannah, GA.	12/15/78	12/20/78
48	Thomasson Lumber Co. Inc. (Hugh Thomason) Philadelphia, Mississippi	12/15/78	12/20/78
49	Ill. Dept. of Transp. Springfield, ILL.	12,18/78	12/29/78
50	Colfax Creosoting Co. Pineville, LA.	12/15/78	12/29/78
51	Ms. Powder Southern Electric System Gulfport, MS.	12/21/78	12/29/78
52	Leonard Guss Associates, Inc (J.B. Bonney) Tacoma, Washington	12/20/78	12/29/78
53	South Texas Cotton & Grain Association, Inc Victoria, Texas	12/11/78	12/19/78
54	Otter Tail Power Co. Fergus Falls, MN.	12/22/78	12/29/78
55	United Marine Publishing, Inc. Kemah, Texas	12/20/78	12/29/78
56	Josh Tillinghast Kemah, Texas	12/19/78	12/29/78
57	State Department of Highways Denver, Colorado	12/14/78	12/29/78
58	Wm. A. Smith Contracting Co., Inc. Shawnee Mission, Kansas	12/20/78	12/29/78
59	Southern Wood Piedmont co. Spartanburg, S.C.	12/19/78	1/2/79
59A	Southern Wood Piedmont Co. Spartanburg, S.C.	2/6/79	2/13/79
60	Arizona Commission of Horticulture, Phoenix, AZ.	12/20/78	12/27/78

61	Barnes Lumber Corporation Charlottesville, VA.	12/21/78	1/4/78
62	John F. Knupp Conroe, Texas	12/21/78	1/4/78
63	Department of the Army (Engineering Research Ctr. Fort Belovoir, VA.	12/22/78	1/5/79
64	Consumers Power Co. Jackson, Michigan	12/29/78	1/5/79
65	Public Service Company of N.H. Manchester, N.H.	12/21/78	1/4/79
66	Dept. of Transportation FAA, Washington, D.C.	1/3/79	1/5/79
67	Maine Dept. of Transportation Augusta, Maine	12/26/78	1/5/79
68	Ohio Dept. of Transportation Columbus, Ohio	12/26/78	1/5/79
69	Ca. Dept. of Transporation Sacramento, California	12/28/78	1/5/79
70	Conroe, Creosoting Co. (Jesse Rodriquez) Conroe, Texas	12/30/78	1/10/79
70A	Conroe, Creosoting Co. Conroe, Texas	12/30/78	1/10/79
71	Smith-Evans Lumber Company Rome, GA.	1/4/79	1/10/79
72	N.C. State University Raleigh, N.C.	12/15/78	12/28/78
73	H.M. Monty Hawthorne (Fencing Supply Store Conroe, Texas	Undated	1/10/79
74	Fla. Dept of Agriculture & Consumer Service Tallahassee, FLA.	12/22/78	1/10/79
75	State Lumber & Supply Co., Inc. Baton Rouge, LA.	1/5/79	1/10/79
76	US Dept of Agriculture Forest Service Athens, GA.	12/20/78	1/10/79

77	G.S. McClellan Conroe, TX.	12/30/78	1/10/79
78	Lennice Sloan(Timber Distr.) Willis, TX.	12/30/78	1/10/79
79	Jerry Schaller Conroe, Texas	12/30/78	1/10/79
80	Conroe Creosoting Co. (Charline Hawthorne) Conroe, TX.	1/5/79	1/10/79
81	Conroe Creosoting Co. (Marie Henry) Conroe, TX.	12/30/78	1/10/79
82	Conroe Creosoting Co. (George B. Brodnax) Conroe, TX.	12/30/78	1/10/79
83	Conroe Creosoting Co. (W.E. Kolbe) Conroe, TX.	12/30/78	1/10/79
84	Conroe Creosoting Co. (Elmer Wiesinger) Conroe, TX.	12/30/78	1/10/79
85	Conroe Creosoting Co. (James Lumpkin)	12/30/78	1/10/79
86	Conroe Creosoting Co. (Charline Muller) Conroe, TX.	12/30/78	1/10/79
87	City Public Service Board San Antonio, Texas	12/29/78	1/10/79
88	Dept. of Transp. Commonwealth of Pa. Harrisburg, PA.	1/2/79	1/10/79
89	Dept of Agriculture Raleigh, N.C.	12/29/78	1/10/79
90	Apollo Forest Products J. Zimmerman Union City, GA.	12/26/78	1/11/79
91	L&M Lumber Co., Inc. Willis, TX.	12/30/78	1/12/79
92	Univ. of Ca., San Francisco, CA.	12/27/78	1/8/79

93	Utah Dept. of Transp. Salt Lake City, UT.	1/2/79	1/9/79
94	J.E.B. Ransone Lumber Co., Inc. Metaire, LA.	1/9/79	1/12/79
95	Conroe Creosoting Co. Conroe, TX.	12/30/78	1/11/79
96	Stephen F. Austin State University Nacogdoches, TX.	1/11/79	1/17/79
97	Central Wood Preserving, Inc. Slaughter, LA.	1/10/79	1/18/79
98	Philadelphia Elec. Co. Philadelphia, PA.	1/11/79	1/18/79
99	McFarland Cascade C.L. Stoddard	1/9/79	1/18/79
100	Rexham Corp. Earl Huston Matthews, N.C.	1/10/79	1/17/79
101	Pacific Gas & Elec. Co. San Francisco, CA.	1/12/79	1/22/79
102	Stephen F. Austin State University Nacogdoches, TX.	1/12/79	1/25/79
103	Hecla Mining Co. Wallace, Idaho	1/12/79	1/25/79
104	Oregon State University Corvallis, Oregon	1/16/79	1/25/79
105	Lake States Wood Preserving, Inc. Munising, Michigan	1/16/79	1/25/79
106	Julian Ochrymowych New Providence, N.J.	1/23/79	1/29/79
107	Indiana Farm Bureau Cooperative Assn., Inc. Indianapolis, Indiana	1/15/79	1/25/79
108	Koppers Co., Inc. Denver, Colo. (See #109)	1/11/79	1/25/79
109	Koppers Co., Inc. Ontario, California (#108)	1/16/79	1/31/79

110	Barnes Lumber Corp. Charlottesville, VA.	1/24/79	1/31/79
111	Koppers Co., Inc. Pittsburgh, PAA	1/25/79	1/30/79
111A	Koppers Co., Inc. (See #111) Pittsburgh, PA. (Gerald L. Daugherty)	2/12/79	2/12/79
111B	Koppers Company Inc. Pittsburgh, PA.	4/23/79	5/9/79
112	Kopper Co., Inc. Houston, Texas	1/26/79	1/31/79
112A	Koppers Co., Inc. Houston, Texas	1/30/79	2/14/79
113	Koppers Co., Inc. Florence, S.C.	1/26/79	1/31/79
114	Koppers Co., Inc. Oroville, California	1/16/79	1/31/79
115	Vepco Richmond, VA.	1/18/79	1/31/79
115A	Vepco Richmond, VA.	7/12/79	8/10/79
116	A.W. Williams Inspection Co., Inc. Mobile, Alabama	12/7/78	12/13/78
117	N.C. State University Raleigh, N.C.	12/15/78	12/28/78
118	Merion B & Patty Reynolds Allen, Texas	12/19/78	12/30/79
119	Ben L. Scholz Wylie, Texas	12/13/78	1/30/79
120	University of Alabama Tuscaloosa, ALA.	1/31/79	2/7/79
121	Brulin & Company Inc. Indianapolis, Indiana	2/2/79	2/7/79
122	J.N. Kressbach Gillette, N.J.	1/30/79	2/7/79
123	Edison Electric Institute Washington, D.C.	1/31/79	2/2/79

124	H.J. Haemmerlie Gainesville, FLA.	1/29/79	2/1/79
125	Martin Marietta Chemicals Charlotte, N.C.	1/26/79	2/1/79
126	F.A. Bartlette Tree Expert Co., Stamford, CT.	1/24/79	2/1/79
127	W.T. Harris Charlotte, N.C.	1/27/79	2/5/79
128	Richard H. Danielson Atlanta, GA.	1/24/79	2/5/79
129	Southern California Edison Co., Rosemead, California	1/29/79	2/7/79
130	Texas Powder & Light Co., Dallas, Texas	1/26/79	2/7/79
131	B.H. LeSuer Gainesville, FLA.	1/30/79	2/8/79
132	Sumter Wood Preserving Co., Bill Cox Sumter, S.C.	1/24/79	2/5/79
133	Dept. of Agriculture (Science & Educ. Admin) Grand Forks, N.D.	1/30/79	2/8/79
134	Bonide Chemical Co., Inc. Yorkville, N.Y.	1/30/79	2/8/79
135	Honolulu Wood Training Co., LTD. Honolulu, Hawaii	1/31/79	2/8/79
136	Fla. Citrus Mutual Lakeland, FLA.	1/31/79	2/8/79
137	Export Leaf Tobacco Co. Richmond, VA.	2/2/79	2/9/79
138	J.A. Jones Construction Co., Charlotte, N.C.	1/29/79	2/9/79
139	R.O. Watson Wilmington, Delaware	2/1/79	2/9/79
140	Cox Wood Preserving Co., Orangeburg, S.C.	2/5/79	2/12/79
141	Chemical Specialties, Inc. Valdosta, GA.	2/6/79	2/12/79

141A	Chemical Specialties, Inc. Valdosta, GA.	3/21/79	4/3/79
142	Mansonite Corporation Jackson, MS.	1/29/79	2/12/79
143	Texas Forest Service Lufkin, Texas	2/5/79	2/12/79
144	Commissioner of Agriculture (R.V. Brown) Austin, TX.	1/31/79	2/12/79
145	PPG Industries, Inc. (W.R. Harris) Pittsburgh, PA.	2/12/79	2/12/79
145A	PPG Industries, Inc. Pittsburgh, PA.	2/16/79	2/28/79
146	Cleveland Electric Illuminating Co., Cleveland, Ohio	1/23/79	2/1/79
147	Dallas Power & Light Co., Dallas, TX.	2/6/79	2/12/79
147A	Dallas Power & Light Co., Dallas, TX.	8/3/79	8/10/79
148	American Electric Power Service Corporation New York, N.Y.	2/7/79	2/12/79
149	Idaho Power Co., Boise, Idaho	2/9/79	2/13/79
150	Public Service Co. of Oklahoma Tulsa, OK.	2/8/79	2/13/79
151	Carolina Power & Light Co., Raleigh, N.C.	2/8/79	2/13/79
152	Texas Forestry Assoc. Lufkin, TX.	2/7/79	2/13/79
153	Portland General Electric Co., Portland, Oregon	2/8/79	2/13/79
154	Middle South Services, Inc. New Orleans, LA.	2/8/79	2/3/79
155	Central Vermont Public Service Corp., Rutland, VT.	2/9/79	2/13/79

156	Osmose Buffalo, N.Y.	2/9/79	2/13/79
157	Grant Labs Oakland, CA.	2/5/79	2/13/79
158	Texas Electric Service Co., Forth Worth, TX.	2/5/79	2/13/79
159	Upper Peninsula Powder Co., Houghton, Michigan	2/8/79	2/13/79
160	Duke Power Co., (Legal Dept.) Charlotte, N.C.	2/9/79	2/13/79
161	Union Electric Co., St. Louis, MO.	2/8/79	2/13/79
162	M.L., Dale Wayne, Floch, Plummer, Idaho	Undated	2/13/79
163	AZ Public Service Co., Phoeniz, AS.	2/6/79	2/13/79
164	Georgia Power Co., (Southern Elec. System Atlanta, GA.	2/7/79	2/13/79
164A	Georgia Power Co., Atlanta, GA.	2/9/79	2/13/79
165	University of Ca. (Cooperative Extension) Davis, California	2/9/79	2/13/79
165A	Univ. of California Davis, CA.	7/2/79	7/19/79
166	National Cotton Council of America Memphis, TENN.	2/8/79	2/14/79
167	N.Y. Powder Pool Schenectady, N.Y.	2/8/79	2/14/79
168	New England Power Service Westborough, MA.	2/9/79	2/14/79
169	U.S. Dept. of Commerce (Industry & Trade Admin) Washington, D.C.	2/14/79	2/15/79
170	Pa. Electric Co. Johnstown, PA.	2/13/79	2/15/79

171	Nixon, Hargrave, Devans & Doyle (Rep: Rochester Gas & Elec. Corp). Rochester, N.Y.	2/12/79	2/15/79
172	Indianapolis Power & Light Co., Indianapolis, Indiana	2/9/79	2/15/79
173	Ill. Power Co., Decatur, ILL.	2/9/79	2/15/79
174	Tampa Electric Co., Tampa, FLA.	2/9/79	2/15/79
175	Jersey Central Power & Light Co., Morristown, N.J.	2/6/79	2/15/79
176	Central 7 South West Services, Inc. Dallas, TX.	2/8/79	2/15/79
177	New York State Electric & Gas Corp., Binghanton, N.Y.	2/8/79	2/15/79
178	P.A. Power & Light Co., Allentown, PA.	2/9/79	2/15/79
179	Canal Electric Co., Sandwich, MA.	2/9/79	2/15/79
180	Cambridge Electric Co., Cambridge, MA.	2/9/79	2/15/79
181	Iowa Electric & Power Co., Cedar Rapids, Iowa	2/5/79	2/15/79
182	New Bedford Gas & Edison Light Co., New Bedford, MA.	2/9/79	2/15/79
183	Southern States Cooperative Richmond, VA.	21/5/79	2/15/79
184	Niagra Mohawk Power Corp. Syracuse, N.Y.	2/6/79	2/15/79
185	Dept. of Transportation Raleigh, N.C.	2/12/79	2/15/79
186	Bank & Trust Corpus Christi, TX.	1/30/79	2/16/79

187	Colwood Pressure Treated Lumber Co. Inc., Columbia, S.C.	2/5/79	2/15/79
188	Woolfork Chemical Works, Inc., Fort Valley, GA.	2/10/79	2/15/79
189	Dept. of Health, Educ. & Welfare Atlanta, GA.	2/7/79	2/16/79
190	National Ready Mixed Conrete Assoc. Silver Spring, MD.	2/9/79	2/16/79
190A	National Ready Mixed Concrete Assoc. (NRMCA) Silver Spring, Maryland	3/22/79	4/3/79
191	Submitted by Counselor Yaroschuk for S.L. Cowley & Sons Mfg., Hugh, Ok.	2/9/79	2/23/79
192	Kansas Powder & Light Co., Topeka, Kansas	2/12/79	2/22/79
193	Iowa-Illinois Gas & Electric Co., Davenport, Iowa	2/8/79	2/22/79
194	Long Island Lighting Co., Hicksville, N.Y.	2/13/79	2/22/79
195	Public Service Co., of Colorado Denver, Colorado	2/9/79	2/23/79
196	Langley and McDonald Professional Corp., Va. Beach, CA.	2/9/79	2/23/79
197	Detroit Edison Elec, Co., Detroit, MI.	2/5/79	2/23/79
198	Gulf States Utilities Co., Beaumont, TX.	2/9/79	2/23/79
199	Atlantic Electric Atlantic City, N.J.	2/8/79	2/23/79
200	West Penn Power Co., Greensburg, PA.	2/9/79	2/23/79
201	Childscapes, Inc. Atlanta, GA.	2/12/79	2/23/79

202	Wisconsin Public Service Corp., Greenbay, WI.	2/12/79	2/23/79
203	Chilton Paint Co., College Point, N.Y.	2/7/79	2/23/79
204	Cincinnati Gas & Electric Co., Cincinnati Ohio	2/12/79	2/23/79
205	Langdale Company Valdosta, GA.	2/7/79	2/26/79
206	Ohio Edison Akron, Ohio	2/5/79	2/27/79
207	Ridge Lumber Industries, Inc., Lakeland, FLA.	2/15/79	2/28/79
208	C.H. Abrams Lilburn, GA.	2/12/79	2/28/79
209	Koppers Company, Inc. Salisbury, MD.	2/16/79	2/28/79
210	Department of Trans. (Trans. Bldg) Salem, Oregon	2/16/79	2/28/79
211	Senator John Tower W/ Constitutents Ltr, (Commerical State Bank), Sinton, TX.	2/6/79	2/28/79
212	Dept. of Health Services (Health & Welfare Ag.) Berkeley, CA.	2/23/79	3/2/79
213	Texas A&M University College Station, TX.	2/16/79	3/2/79
214	Kaiser Agricultural Chemicals Savannah, GA.	2/22/79	3/5/79
215	Tucson Gas & Electric Co., Tucson, AZ	3/5/79	3/8/79
216	Cities Service Co., (Citco) Atlanta, GA.	2/22/79	3/7/79
217	Minnesota Power & Light Co., Duluth, MN	2/28/79	2/7/79
218	Bowater Carolina Corp., Catawba, S.C.	2/23/79	3/7/79

219	Port of Auth. for New York & New Jersey New York, N.Y.	3/14/79	3/21/79
220	Savannah Elec. and Power Co., Savannah, Ga.	Undated	3/22/79
221	Columbus and Southern Ohio Elec. Co., Columbus, Ohio	3/19/79	3/30/79
222	Dantzler Lumber and Export Co., Jacksonville, FLA.	2/9/79	4/3/79
223	Desoto Chemical Co., Inc., Arcadia, FLA.	3/29/79	4/6/79
224	Harkers Island Elec. Corp., Harkers Island, N.C.	4/3/79	4/10/79
225	Roanoke Electric Corp., Rich Square, N.C.	4/3/79	4/10/79
226	Ohio State University (Div. of Forestry) Columbus, Ohio	3/26/79	4/10/79
227	Continental Divide Elec. Coop. Inc. Springer, New Mexico	4/3/79	4/10/79
228	Springer Elec. Coop. Inc., Springer, New Mexico	/4/79	4/11/79
229	East Ms. Electric Power Assoc. Merdian, Ms.	4/5/79	4/11/79
230	Rio Grande Electric Coop. Inc. Brackettville, TX.	4/5/79	4/11/79
231	Adams Electric Coop. Inc. Gettysburg, Pa.	4/5/79	4/11/79
232	Nebraska Electric Generation Trans. Coop. Inc., Columbus, Nebraska	4/4/79	4/11/79
233	Southern Pine Electric Coop. Brewton, Alabama	4/9/79	4/13/79
234	Southeast Elec. Corp. Inc., Ekalaka, Montona	4/5/79	4/13/79

235	Halifax Elec. Membership Corp. Enfield, N.C.	4/6/79	4/13/79
236	Logan Country Co-op Power and Light Assoc, Inc. Bellefontaine, Ohio	4/4/79	4/13/79
237	Tallapoosa River Elec. Coop. LaFayette, Alabama	4/5/79	4/13/79
238	Harney Electric Coop.. Inc., Burns, Oregon	4/6/79	4/13/79
239	Tri-Country Elec. Membership Corp., Goldsboro, N.C.	4/9/79	4/13/79
240	Lincoln Electric Corp., Eureka, Montana	4/9/79	4/13/79
241	Northeast Missouri Electric Power Coop. Palmyra, MO.	4/4/79	4/13/79
242	The Victory Elec. Coop., Assoc., Inc. Dodge City, Kansas	4/9/79	4/17/79
243	United Elec. Coop., Inc., Dubois, PA.	4/10/79	4/17/79
244	Okefenoke Rual Elec. Membership Corp., Nahunta, GA.	4/9/79	4/17/79
245	Golden Valley Elec. Assoc., Inc., Fairbanks, Alaska	4/5/79	4/17/79
246	Re Sand Mountain Elec. Coop., Rainsville, Ala.	4/9/79	4/17/79
247	EMC Haywood Elec. Membership Corp., Waynesville, N.C.	4/11/79	4/17/79
248	Flint Hills Rural Elec. Coop., Assn., Inc., Council Grove, KS	4/9/79	4/17/79
249	Alger Delta Coop., Elec. Assoc., Gladstone, MI	4/12/79	4/18/79

250	Slope Elec. Coop., Inc., New England, N.D.	4/12/79	4/18/79
251	York Country Rural Public Power District York, Nebraska	4/13/79	4/20/79
252	Mitchell Elec. Membership Corp., Camilla, GA.	4/11/79	4/20/79
253	Flathead Elec. Coop., Inc., Power & Light Kalispell, Montana	4/12/79	4/20/79
254	North-Central Elec. Coop., Inc., Attica, Ohio	4/12/79	4/20/79
255	Shenandoah Valley Elec. Coop., Inc., Dayton, VA.	4/11/79	4/20/79
256	Sac Osage Elec. Coop., El Dprado Springs, MO.	4/9/79	4/20/79
257	Cavalier Rural Elec. Coop., Inc., Langdon, N.D.	4/11/79	4/20/79
258	Wheatland Rural Elec. Assoc., Wheatland, Wyoming	4/11/79	4/20/79
259	Beauregard Elec. Co-op., Inc., De Ridder, LA.	4/6/79	4/20/79
260	Peace River Elec. Coop., Inc., Andalusia, Alabama	4/17/79	4/24/79
261	Covington Elec. Coop., Inc., Andalusia, Alabama	4/18/79	4/24/79
262	EMC Blue Ridge Elec. Membership Corp., Lenoir, N.C.	4/23/79	4/26/79
263	Verendrye Elec. Coop., Inc., Velva, N.D.	4/23/79	4/30/79
264	Wise Elec. Coop., Inc., Decature, TX.	4/18/79	4/30/79
265	Sumter Elec. Membership Corp., Americus, GA.	4/19/79	4/30/79
266	Lower Valley Power & Light, Inc., Afton, Wyoming	4/19/79	4/30/79

267	Shelby Rural Elec. Coop., Corp., Shelbyville, KY	4/20/79	4/30/79
268	Harricon Country Rural Elec. Membership Corp. Corydon, Indiana	4/20/79	5/1/79
269	Edgecombe-Martin Country Electric Membership Corp., Tarboro, N.C.	4/26/79	5/4/79
270	Kosciusko Country Rural Elec. Membership Corp. Warsaw, Indiana	4/30/79	5/4/79
271	Jackson Elec. Membership Corp., Jefferson, GA	4/27/79	5/4/79
272	Fairfield Elec. Coop., Inc., Winnsboro, S.C.	4/27/79	5/4/79
273	Barc Elec. Coop., Millsboro, VA	4/30/79	5/4/79
274	Habersham Elec. Membership Corp., Clarkesville, GA	4/25/79	5/4/79
275	Western Illinois Elec. Coop., Carthage, IL	4/24/79	5/4/79
276	Hickman-Fulton Countries Elec. Coop., Corp., Hickman, KY	4/30/79	5/4/79
277	Washington State Univ. Pullman, Washington	5/3/79	5/9/79
278	American Institute of Timber Construction Englewood, Colorado	5/2/79	5/9/79
279	Oliver B. Wilbers Umpqua, OR.	4/7/79	5/17/79
280	Oliver-Mercer Elec. Coop. Inc. Hazen, N.D.	5/9/79	5/17/79
281	Green River Elec. Corp., Owensbror KY.	6/5/79	6/14/79
282	Alabama Power Co. Birmingham, ALA.	6/15/79	6/22/79

283	U.S. Dept. of Agricul. Forest Service Asheville, N.C.	6/15/79	6/28/79
284	DOD, OASD (G. Marienthal) Washington, D.C.	6/27/79	7/12/79
285	Montana State Univ. Bozeman, Montanna	7/16/79	8/2/79
286	McKenzie Elec. Co-op. Watford, N.D.	7/13/79	8/10/79
287	Interstate Power Co. Dubuque, Iowa	8/2/79	8/16/79
288	National Rural Electric Coop. Washington, D.C.	8/22/79	8/22/79

LISTING OF REBUTTAL COMMENTS-PENTACHLOROPHENOL

Rebuttal No.	Source	Date of Comment	Date Received
1	Steptoe and Johnson, Atts. (Rep. American Wood Preservers Inst.) Washington, D.C.	10/23/78	11/2/78
See 1A, 1B	Steptoe & Johnson Washington, D.C.	4/27/79	5/1/79
2	Reichhold Chemicals, Inc. White Plains, N.Y.	11/7/78	11/13/78
3	Cooperative Ext. Service Fitzgerald, Ga.	11/3/78	11/13/78
4	Chapman Chemical Co. Memphis, Tn.	11/6/78	11/15/78
5	Emerald Turfgrass Farms Seattle, Washington	11/16/78	11/20/78
6	Department of the Navy Alexandria, Va.	11/17/78	11/20/78
7	Agro-West, Inc. Wilder, Idaho	11/10/78	11/20/78
8	Link Noe, Wilder Bldg. Ctr. Wilder, Idaho	11/10/78	11/20/78
9	Consolidated Companies Cleveland, Ohio	11/21/78	11/24/78
10	George Brown Idaho Falls, Idaho	11/16/78	11/27/78
11	Howard Larson Emmett, Idaho	11/13/78	11/29/78
See 11 11A	Howard Larson Emmett, Idaho	1/22/79	2/13/79
12	Chas. H. Lilly Co. Portland, Oregon	11/15/78	11/29/78
13	L.A. Tephson	UNDATED	11/29/78
14	Edward Hener	11/17/78	11/24/78
15	Ray S. Buker Teton, Idaho	11/18/78	11/24/78

16	Ray B. Andrews Idaho Falls, Idaho	UNDATED	11/24/78
17	Debbin Johnson	UNDATED	11/24/78
18	Dow Chemical (See 18A, 18B, 18C) Midland, Michigan	11/16/78	11/24/78
18B	Dow Chemical Co. (See 18, 18A, 18C 6 Vols.) Midland, Michigan	2/12/79	2/12/79
19	L.D. McFarland Co. Sandpoint, Idaho	11/21/78	11/27/78
20	Phil Baker Teton, Idaho	UNDATED	11/29/78
21	Reo & George Archibald Rexburg, Idaho	11/23/78	11/29/78
22	OM Scott & Sons Marysville, Ohio	11/21/78	11/29/78
23	Robert Swanson Idaho Falls, Idaho	11/22/78	11/29/78
24	Dean Schwendiman Newdale, Ohio	11/17/78	11/29/78
25	Harry Field Rigby, Idaho	11/22/78	11/29/78
26	National Chemical Manufacturers Atlanta, Georgia	11/20/78	11/29/78
27	O. Ray Hall Rexburg, Idaho	UNDATED	12/5/78
28	Amle Landon Rigby, Idaho	UNDATED	12/5/78
29	Kalispell Pole & Timber Company Kalispell, Montana	11/28/78	12/5/78
30	James Siddoway Teton, Idaho	UNDATED	12/5/78
31	Commonwealth of Pa. (Dept. of Environmental Resources) Harrisburg, Pa.	11/29/78	12/5/78

32	Chevron Chemical Co. Richmond, California	11/27/78	12/5/78
33	Union Oil Company of California, Union Chemicals Division	11/29/78	12/5/78
34	Gibson-Homans Company Cleveland, Ohio	11/30/78	12/6/78
35	Dept. of Transportation and Public Facilities Juneau, Alaska	11/30/78	12/5/78
35A	Dept. of Transportation & Public Facilities State of Alaska	12/12/78	12/21/78
35B	Dept. of Transportation & Public Facilities Juneau, Alaska (See 35 & 35A)	12/19/78	12/29/78
36	Johnny L. Crawford Chula, Georgia	11/22/78	12/6/78
37	Potomac Electric Power Co. Washgington, D.C.	11/28/78	12/6/78
See 37 37A	Potomac Electric Co. Washington, D.C.	2/12/79	2/13/79
See 38 38A	Central Hudson Gas & Electric Corp. Poughkeepsie, N.Y.	2/9/79	2/13/79
38	Central Hudson Gas & Electric Corporation Poughkeepsie, N.Y.	11/27/78	12/6/78
39	Louis Shirl	UNDATED	12/6/78
40	John M. Brown Tetonia, Idaho	11/28/78	12/6/78
41	Jasco Chemical Corp. Mountain View, California	11/30/78	12/6/78
42	Pacific Power & Light Co. Portland, Oregon	12/1/78	12/6/78
43	Allan Ravenscroft Tuttle, Idaho	11/29/78	12/6/78

43A	Bryan Ravenscroft Tuttle, Idaho	11/29/78	12/6/78
44	Vernon Ravenscroft Tuttle, Idaho	11/29/78	12/6/78
45	Kansas Department of Transportation Topeka, Kansas	12/1/78	12/6/78
46	Industrial Water Chemicals Chattanooga, Tenn.	12/4/78	12/7/78
47	Public Service Electric & Gas Company Newark, N.J.	12/1/78	12/6/78
48	Henry J. Ellis Manchester, N.H.	12/4/78	12/8/78
49	Fla. Power & Light Co. Miami, Fla.	11/30/78	12/8/78
50	Osborne A. Goetz Idaho Falls, Idaho	UNDATED	12/8/78
51	Midland Research Labs. Houston, Texas	12/4/78	12/8/78
52	Lester Labs., Inc. Atlanta, Georgia	12/5/78	12/8/78
53	Herman Ratner Atlantic City, N.J.	12/4/78	12/8/78
54	Jewel Hansen Rexburg, Idaho	UNDATED	12/11/78
55	Tullio Gabos Vineland, N.J.	12/5/78	12/11/78
56	Chemical Treatment Co. Ashland, N.J.	12/5/78	12/11/78
57	Industrial Maintenance Corp., Charlotte, N.C.	12/6/78	12/11/78
58	Reliance Brooks Inc. Cleveland, Ohio	12/5/78	12/11/78
59	Arkansas State Plant Board Little Rock, Arkansas	12/5/78	12/11/78

60	Harris Chemical Co., Inc. Knozville, Tenn.	12/5/78	12/11/78
61	Chem-Masters Corp., Chagrin Falls, Ohio	12/4/78	12/11/78
62	Water Services, Inc. Knoxville, Tenn.	12/5/78	12/11/78
63	Dept. of Agriculture Atlanta, Gerogia	12/5/78	12/11/78
64	Dept. of Highways & Transportation Richamond, Virginia	12/1/78	121178
65	Kor-Chem Atlanta, Georgia	12/8/78	12/13/78
66	Branchemco Inc. Jacksonville, Fla.	12/5/78	12/13/78
67	A.W. Williams Inspection Company Mobile, Alabama	12/7/78	12/13/78
68	Allegheny Power System Greensburg, Pa.	12/7/78	12/13/78
69	Arkansas Power & Light Company Little Rock, Arkansas	12/4/78	12/13/78
70	University of Illinois at Urbana-Champaign Urbana, Illinois	12/5/78	12/13/78
71	Dayton Power & Light Co. Dayton, Ohio	12/1/78	12/13/78
72	Department of Transportation Dover, Delaware	12/7/78	12/13/78
73	Blumberg Co. Peabody, Mass.	12/8/78	12/13/78
74	Watcon, Inc. South Bend, Indiana	12/7/78	12/13/78
75	Long Chemical Inc. Los Angelas, California	12/6/78	12/13/78
76	Mac Gillis & Gibbs Co. Milwaukee, Wisconsin	12/8/78	12/13/78

77	Brenco Corporation St. Louis, Missouri	12/11/78	12/18/78
78	National Chemsearch Irving, Texas	12/13/78	12/18/78
79	Alabama Power Electric System Birmingham, Ala.	12/5/78	12/18/78
80	Dept. of Agriculture Saint Paul, Minnesota	12/12/78	12/18/78
81	Atlantic Chemical & Equipment Co. Atlanta, Georgia	12/13/78	12/20/78
82	Norman Chemical Co. St. Paul, Minn.	12/13/78	12/20/78
83	Unichem International Hobbs, N.M.	12/14/78	12/20/78
84	Faultless Pest Control Inc. (H.L. Coleman) Kansas City, Kansas	12/12/78	12/20/78
85	Department of Agriculture Annapolis, Md.	12/13/78	12/20/78
86	Department of Interior Washington, D.C.	12/13/78	12/20/78
87	New Orleans Public Service Inc. New Orleans, La.	12/1/78	12/13/78
88	Dept. of Agriculture (Kent D. Shelhamer) Commonwealth of Pa.	12/12/78	12/20/78
89	Atlantic Wood Industries Inc. (A.G. Labrot) Savannah, Georgia	12/15/78	12/21/78
90	Precision Chemicals (M.W. Fletcher) Atlanta, Georgia	12/13/78	12/21/78
91	Atlantic Wood Industries (A.G. Labrot) Savannah, Ga. (See #89)	12/15/78	12/21/78
92	Atchison, Topeka & Santa Fe RR Co. Chicago, Ill.	12/13/78	12/21/78

93	Potomac Edison Co. Hagerstown, Md.	12/15/78	12/21/78
94	Dept. of Transportation State of Idaho	12/14/78	12/21/78
95	Dept. of Agriculture Agana, Guam	12/13/78	12/21/78
96	Thomasson Lumber Co. Inc. (Hugh Thomasson) Philadelphia, Mississippi	12/15/78	12/22/78
97	Ill. Dept of Transportation (Bureau of Materials & Physical Res.) Springfield, Ill.	12/18/78	12/29/78
98	Colfax Creosoting Co. Pineville, Louisanna	12/15/78	12/29/78
99	Miss. Power Southern Electric System Gulfport, Miss.	12/21/78	12/29/78
100	Leonard Guss Associates, Inc. Tacoma, Washington.	12/20/78	12/29/78
101	Vermont Agency of Transportation (Eng. & Constr) Montpelier, Vermont	12/22/78	12/29/78
102	United Marine Publishing, Inc. Kemah, Texas	12/20/78	12/29/78
103	R&M Consultants, Inc. Anchorage, Alaska	12/21/78	12/29/78
104	Dept of Transportation (U.S. Coast Guard) Juneau, Alaska	12/19/78	12/29/78
105	American Seal Mfg. Co., Inc. Troy, N.Y.	12/21/78	12/29/78
106	Wm. A. Smith Contracting Co., Inc. Shawnee Mission, Kansas	12/20/78	12/29/78
107	State Dept. of Highways (Col. State Patrol) Denver, Colorado	12/14/78	12/29/78

108	American Water Treatment, Inc. St. Louis, Missouri	12/19/78	12/29/78
109	Bonners Ferry Post Co. Bonners Ferry, Idaho	12/19/78	12/29/78
110	Omaha Public Power District Omaha, Nebraska	12/19/78	12/29/78
111	Tri-Copunty Electric Cooperative Rushford, Minnesota	12/22/78	12/29/78
111A	Tri-County Electric Cooperative Rushford, Minnesota		4/11/79
112	Otter Tail Power Co. Fergus Falls, Minnesota	12/22/78	12/29/78
113	Southern Wood Piedmont Co. Spartanburg, S.C.	12/19/78	12/29/78
See 113 113A	Southern Wood Piedmont Co. Spartanburg, S.C.	2/6/79	2/13/79
114	Ohio Dept. of Agriculture Columbus, Ohio	12/22/78	1/5/79
115	Department of the Army Engineering Res. Ctr., Fort Belvoir, Va.	12/22/78	1/5/79
116	Public Service Co. of New Hampshire Manchester, New Hampshire	12/21/78	1/4/79
117	Indiana State Highway Indianapolis, Indiana	12/27/78	1/5/79
118	Consumers Power Company Jackson, Michigan	12/29/78	1/5/79
119	Dept. of Transportation Sacramento, California	12/28/78	1/5/79
120	Ohio Department of Transportation Columbus, Ohio	12/26/78	1/5/79
121	Dept. of Transportation Federal Aviation Administrarton Washington, D.C.	1/3/79	1/5/79

122	Maine Department of Transportation Augusta, Maine	12/26/78	1/5/79
123	Conroe Creosoting Company (J.A. Ramey) Conroe, Texas	12/30/79	1/10/79
123A	Conroe Creosoting Company (Charline H. Muller) Conroe, Texas	12/30/78	1/10/79
123B	Conroe Creosoting Company (James P. Lumpkin) Conroe, Texas	12/30/78	1/10/79
123C	Conroe Creosoting Company (Elmer Weisinger)	12/30/78	1/10/79
123D	Conroe Creosoting Company (W.E. Kolbe) Conroe, Texas	12/30/78	1/10/79
123E	Conroe Creosoting Company (George B. Brodnax) Conroe, Texas	12/30/78	1/10/79
123F	Conroe Creosoting Company (Marie Henry) Conroe, Texas	12/30/78	1/10/79
123G	Conroe Creosoting Company (Charline Hawthorne) Conroe, Texas	12/30/78	1/10/79
124	Fla. Dept. of Agriculture & Consumer Services Tallahassee, Fla.	12/22/78	1/10/79
125	N.C. Dept. of Agriculture (Commissioner) Raleigh, N.C.	12/29/78	1/10/79
126	Dept. of Transportation (Pa. Ofc. of Secretary) Harrishurg, Penna.	1/2/79	1/10/79
127	City Public Service Board San Antonio, Texas	12/29/78	1/10/79
128	G. Carl Baton (C&B Timber) Ashton, Idaho.	12/31/78	1/10/79

129	Lok N Logs Inc. (James l. Webb) Sherburne, N.Y.	12/21/78	1/10/79
130	Jerry Schaller Conroe, Texas	12/30/78	1/10/79
131	Lennice Sloan (Timber Distribution) Willis, Texas	12/30/78	1/10/79
132	Hughes Brothers (S.F. Smith) Seward, Nebraska	1/4/79	1/10/79
133	G.S. McClellan Conroe, Texas	12/30/78	1/10/79
134	H.M. Monty Hawthorne (Fencing Supply Store) Conroe, Texas	UNDATED	1/10/79
135	N.C. State University Raleigh, N.C.	12/15/78	12/28/78
123H	Conroe Creosoting Company (V.L. Andrews) Conroe, Texas	12/30/78	1/11/79
136	University of California San Francisco San Francisco, California	12/27/78	1/11/79
137	L&M Lumber Co., Inc. (Mickey McMillin) Willis, Texas	12/30/78	1/12/79
138	Walton, Feed, Inc. (Steve) Montpelier, Idaho	1/13/79	1/17/79
139	Monogahela Power Co. Fairmont, West Va.	1/12/79	1/17/79
140	Stephen F. Austin State University (Leonard F. Burkart) Nacogdoches, Texas	1/11/79	1/17/79
141	J. Whittaker Leadore, Idaho	UNDATED	1/17/79
142	McFarland Cascade Sandpoint, Idaho	1/9/79	1/18/79

143	Philadelphia Electric Co. Philadelphia, Penna.	1/11/79	1/18/79
144	South Jersey Exterminating Corporation Camden, N.J.	1/10/79	1/18/79
145	Wayne W. Roundy Boise, Idaho	1/10/79	1/18/79
146	Allen Bauscher Fairfield, Idaho	UNDATED	1/18/79
147	Elco Manufacturing Co. Inc. (Harry Katz) Pittsburgh, Penna.	1/16/79	1/22/79
148	Rexham Corporation (Industrial Division) Matthews, N.C.	1/10/79	1/17/79
149	Pacific Gas and Electric Company San Francisco, California	1/12/79	1/22/79
150	Yakima County Farm Bureau Yakima, Washington	1/17/79	1/24/79
151	Burton Sav Minneapolis, Minn.	1/19/79	1/24/79
152	Ham Paint Supply Minneapolis, Minn.	1/19/79	1/24/79
153	Koss Paint and Wallpaper Inc. Hopkins, Minn.	1/19/79	1/24/79
154	St. Germain Bros. Inc. Duluth, Minn.	UNDATED	1/24/79
155	Fred Bolt Paint & Wallpaper Co. Inc. St. Paul, Minn.	1/19/79	1/24/79
156	Fleet Distributing Supply Wadena, Minn.	1/79	1/24/79
157	Fleet Distributing Supply Company Little Falls, Minn.	1/19/79	1/24/79
158	Bemidji Fleet Distribution Bemidji, Minn.	1/19/79	1/24/79

159	Haberman Supplies Owatonna, Minn.	1/19/79	1/24/79
160	Lyle H. Guggishery St. Cruix, Wi.	1/19/79	1/24/79
161	Koppers Company Inc. Denver, Col.	1/11/79	1/25/79
162	John J. Pennington Eugene, Oregon	1/14/79	1/25/79
163	Gordon A. MacGregor Boise, Idaho	1/15/79	1/25/79
164	Interstate Power Co. Dubuque, Iowa	1/18/79	1/25/79
See 164 A	Interstate Power Co., Dubuque, Iowa	8/2/79	8/16/79
165	Edison Sault Electric Co. Sault Ste. Marie, Michigan	1/16/79	1/25/79
166	Oregon State University (Theodore C. Scheffer) Corvallis, Oregon	1/16/79	1/25/79
166A	Oregon State University (R.D. Graham) Corvallis, Oregon	1/17/79	1/25/79
167	Indiana Farm Bureau Cooperative Assn., Inc.	1/15/79	1/25/79
168	Lake States Wood Preserving Inc. Munising, Michigan	1/16/79	1/25/79
169	C.K. Peck Lexington, Oregon	1/7/79	1/24/79
170	Houston Wood Treating Co., Inc. Houston, Missouri	1/18/79	1/29/79
171	Decorator Supply Inc. (J.F. Schellien) Rice Lake, Wi.	UNDATED	1/26/79
172	Fleet Distribution Supply Thief River Falls, Minn.	1/20/79	1/26/79
173	Anderson Glass Co., Inc. Grand Rapids, Minn.	1/18/79	1/26/79

174	G.F. Nemitz' Sons Hutchison, Minn.	1/19/79	1/26/79
175	Kenneth P. Strube Rochester, Minn.	1/19/79	1/26/79
176	Gordon A. Peterson Dresser, Wi.	1/20/79	1/26/79
177	Jan J. Don Grandview, Washington	1/22/79	1/30/79
178	Wayne W. Roundy Boise, Idaho	1/23/79	1/30/79
179	Vepco Richmond, Va.	1/18/79	1/30/79
179A	Vepco Richmond, Va.	1/18/79	8/9/79
See 179 179A	Vepco Richmond, VA.	7/12/79	8/10/79
180	Koppers Company Inc. (194) Pittsburgh, Pa. (See 161, 183, 188, 189, 192, 193 & 194)	1/25/79	1/30/79
180A	Koppers Co. Inc., (Gerald L. Daugherty) Pittsburgh, Pa. (See 180)	2/12/79	2/12/79
180B	Koppers Company Inc. (194) Pittsburgh, Pa. (See 161. 183, 188, 189, 192, 193 & 194)	1/25/79	2/12/79
181	Kansas Gas & Electric Co Witchita, Kansas	1/23/79	1/30/79
182	New England Log Homes Inc. Hamden, Conn.	1/22/79	130/79
183	Koppers Company Inc. Superior, Wi.(See 161, 180, 188, 189, 192, 193, 194)	UNDATED	1/29/79
184	Julian Ochrymowych New Providence, N.J.	1/23/79	1/29/79

185	Central Illinois Public Service Co. Springfield, Ill.	1/22/79	1/29/79
186	Benjamin H. Adkins Louisville, Kentucky	1/23/79	1/29/79
187	Willard Schoenfeld Redwood City, Ca.	1/20/79	1/29/79
188	Koppers Company Inc. (See 161, 180, 183, 189, 192, 193,194) North Little Rock, Ark.	1/8/79	1/29/79
189	Koppers Co. Inc. (See 161, 180, 183, 188, 192, 193, 194) Tie Plant, Ms.	1/22/79	1/29/79
190	VOID		
191	William A. Rich Minneapolis, Mn.	1/9/79	1/31/79
192	Koppers Co. Inc. Florence, S.C. (See 161, 180, 183, 188, 189, 193 & 194)	1/26/79	1/31/79
193	Koppers Co. Inc. (See Above)	1/26/79	1/31/79
See 193 193A	Koppers Co. Inc. Houston, Tx.	1/30/79	2/14/79
194	Koppers Co., Inc. Oroville, Ca.	1/16/31	1/31/79
195	F.A. Bartlett Tree Co. (Robert Bartlet) Stamford, Ct.	1/24/79	2/1/79
196	Martin Marietta Chemicals Charlotte, N.C.	1/26/79	2/1/79
197	Dept. of Public Instruction (C.V. Tart) Raleigh, N.C.	1/23/79	2/1/79
198	H.J. Haemmerlie Gainesville, Fla.	1/29/79	2/1/79

199	Shoppers Supply Div. Schmidt Distr. Inc. Spencer, Iowa	1/25/79	2/1/79
200	Andren's Inc. Duluth, Mn.	1/24/79	2/1/79
201	Edison Electric Institute Washington, D.C.	1/31/79	2/2/79
202	Koppers Co. Inc. Nashua, N.H. (Charles H. Fereday)	1/29/79	2/2/79
202A	Koppers Company Inc. Nashua, N.H. (John L. Peterson)	1/29/79	2/2/79
203	W.T. Harris Charlotte, N.C.	1/27/79	2/5/79
204	J.T. Thornton Dora, Mo.	1/22/79	2/5/79
205	Richard H. Danielson Atlanta, Ga.	1/24/79	2/5/79
206	J.N. Kressbach Gillette, N.J.	1/30/79	2/7/79
207	Louisiana-Pacific Corp. Escanaba, Michigan	1/31/79	2/7/79
208	Southern California Edison Co., Rosemead, California	1/29/79	2/7/79
209	Simonsen Chemical Co., Inc. Cabool, Mo.	1/15/79	2/7/79
210	Texas Power & Light Co. Dallas, Texas	1/26/79	2/7/79
211	Ace Hardware Corp., Oak Brook, Ill.	1/29/79	2/8/79
212	Charlie Reed Rosalia, Washington	1/26/79	2/8/79
213	B.H. LeSueur Gainesville, Fla.	1/30/79	2/8/79
214	Export Leaf Tobacco Co. Richmond, Va.	2/2/79	2/9/79

215	J.A. Jones Construction, Co. Charlotte, N.C.	1/29/79	2/9/79
216	R.O. Watson Wilmington, Delaware	2/1/79	2/9/79
217	Avco New Idea (Farm Equipment Division) Coldwater, Ohio	2/1/79	2/9/79
218	Rogers Post & Lumber Co. Steelville, Missouri	1/29/79	2/9/79
219	Cleveland Electric Illuminating Co. Cleveland, Ohio	1/23/79	2/1/79
220	Robert K. Hastings Harbor, Oregon	1/29/79	2/12/79
221	Friends of the Earth (Erik Jansson) Washington, D.C.		
222	Texas Forest Service Lufkin, Tx.	2/6/79	2/12/79
223	Web & Sons Inc. Sherburne, N.Y.	UNDATED	2/12/79
224A	Dallas Power & Light Co. Dallas, Texas	2/6/79	2/12/79
See 224 224 A	Dallas Power & Light Dallas, TX.	8/3/79	8/10/79
225	American Electric Power Service Corp.	2/6/79	2/12/79
226	Public Service Co., of New Mexico Albuquerque, N.M.	2/9/79	2/12/79
227	W.C. Timber Products, Inc. (T.F. Cliften) Rexburg, Idaho	2/8/79	2/13/79
228	Idaho Power Co. Boise, Idaho	2/9/79	2/13/79
229	Public Service Co. of OK. Tulsa, OK.	2/8/79	2/13/79

230	Carolina Power & Light Co. Raleigh, N.C.	2/8/79	2/13/79
231	Roof Surgeon Inc. Honolulu, Hawaii	2/9/79	2/13/79
232	Texas Forestry Assoc. Lufkin, Tx.	2/7/79	2/13/79
233	Portland General Electric Co. Portland, Oregon	2/8/79	2/13/79
234	Morton Buildings, Inc. Morton, Ill.	2/7/79	2/13/79
235	Middle South Services Inc. New Orleans, La.	2/8/79	2/13/79
236	Central Vermont Public Service Corp. Rutland, Vt.	2/9/79	2/13/79
237	Texas Electric Service Co. Fort Worth, Tx.	2/5/79	2/13/79
238	Upper Peninsula Power Co. Houghton, Michigan	2/8/79	2/13/79
239	Duke Power Co. (Legal Dept.) Charlotte, N.C.	2/9/79	2/13/79
240	Union Electric Co. St. Louis, Mo.	2/8/79	2/13/79
241	Bill Deveny Riggins, Idaho	1/22/79	2/13/79
242	Everett Van Seyke Wilder, Id.	UNDATED	2/13/79
243	Mark Johnson, Idaho	1/21/79	1/13/79
244	Reuben H. Babcock Moore, Idaho	2/1/79	2/13/79
245	Picabo Livestock Co. Picabo, Idaho	1/18/79	1/13/79
246	Don Heckman White Bird, Idaho	UNDATED	2/13/79

247	M.L., Dale, Wayne Floch Plummer, Idaho	UNDATED	2/13/79
248	North Side Canal Co. Jerome, Idaho	1/26/79	2/13/79
249	M.T. Laurmin Casper, Wy.	UNDATED	2/13/79
250	Az. Public Service Co. Phoenix, Az.	2/6/79	2/13/79
251	Georgia Power Co. Atlanta, Ga.	2/7/79	2/13/79
251A	Georgia Power Co. Atlanta, Ga.	2/7/79	2/13/79
See 251 251 A	Georgia Power Co., Atlanta, GA.	8/14/79	8/20/79
252	Univ. of Calif. (Cooperative Ext.) Davis, Ca.	2/9/79	2/13/79
252A	Univ. of Calif. (Cooperative Ext.) Davis, Ca.	2/9/79	2/13/79
252 B	Univ. of Calif Davis, CA.	7/2/79	7/19/79
253	Northeast Utilities Hartford, Ct.	2/7/79	2/13/79
254	Vulcan Materials Co. Birmingham, Ala.	2/8/79	2/14/79
255	N.Y. Power Pool Schenectady, N.Y.	2/8/79	2/14/79
256	Iowa Power & Light Co. Des Moines, Iowa	UNDATED	2/14/79
256A	Iowa Electric Light & Power Co. Cedar Rapids, Iowa	2/5/79	2/15/79
257	New England Power Service Westborough, Mass.	2/9/79	2/14/79
258	U.S. Dept. of Commerce (Industry & Trade Admin.) Washington, D.C.	2/14/79	2/15/79

259	Pa. Electric Co. Johnstown, Pa.	2/12/79	2/15/79
260	Nixon, Hargrave, Devans & Doyle(Rep: Rochester Gas & Elec. Corp.) Rochester, N.Y.	2/12/79	2/15/79
261	Indianapolis Power & Light Company Indianapolis, Indiana	2/12/79	2/15/79
262	Ill. Power Co. Decatur, Ill.	2/9/79	2/15/79
262A	Illinois Power Company Decatur, Ill.	3/14/79	3/20/79
263	Tampa Electric Co. Tampa, Fla.	2/9/79	2/15/79
264	Jersey Central Power & Light Co. Morristown, N.J.	2/6/79	2/15/79
265	Central & South West Services, Inc. Dallas, Tx.	2/8/79	2/15/79
266	New York State Electric & Gas Corporation Binghamton, N.Y.	2/8/79	2/15/79
267	Pa. Power & Light Co. Allentown, Pa.	2/9/79	2/15/79
268	Canal Electric Co. Sandwich, Mass.	2/9/79	2/15/79
269	Cambridge Electric Light Cambridge, Mass.	2/9/79	2/15/79
270	New Bedford Gas & Edison Light Co. Duluth, Minn.	2/9/79	2/15/79
271	Southern States Cooperative Richmond, Va.	2/5/79	2/15/79
272	Niagra Mowhawk Power Corporation Syracuse, N.Y.	2/6/79	2/15/79
273	Minnesota Power & Light Co. Duluth, Mn.	2/8/79	2/15/79

273A	Minnesota Power & Light Co. Duluth, Minn.	2/28/79	3/7/79
274	Boston Edison Co. Boston, Mass.	2/5/79	2/15/79
275	American Paper Institute Washington, D.C.	2/12/79	2/15/79
275A	Lumber River Elec. Membership Corp.		4/17/79
276	Dept. of Transportation Raleigh, N.C.	2/12/79	2/15/79
277	Delsea Exterminators Camden, N.J.	2/7/79	2/16/79
278 278A	Forshaw Chemicals Charlotte, N.C.	2/8/79	2/16/79
279	The Washington Water Power Co. Spokane, Washington	2/12/79	2/22/79
280	Kansas Power & Light Co. Topeka, Ks.	2/12/79	2/22/79
281	Iowa-Illinois Gas & Electric Co. Davenport, Iowa		
282	National Solvent Corp., Medina, Ohio	2/11/79	2/22/79
283	Lincoln Electric Coopera- tive Inc. Davenport, Washington	2/12/79	2/22/79
284	Ron Frei Grangeville, Idaho	UNDATED	2/22/79
285	Long Island lighting Co. Hicksville, N.Y.	2/13/79	2/22/79
286	University of Idaho, Coll. of Agriculture Dept. of Agri., Moscow, Idaho	1/31/79	2/22/79
287	Public Service Co. of Colorado Denver, Colorado	2/9/79	2/23/79

288	Langley and McDonald Professional Corp., Va. Beach, Va.	2/9/79	2/23/79
289	L.E. Fake Charlotte, N.C.	UNDATED	2/23/79
290	Detroit Edison Electric Co. Detroit, Mi.	2/5/79	2/23/79
291	Gulf States Utilities Co. Beaumont, Tx.	2/9/79	2/23/79
292	Atlantic Electric Atlantic City, N.J.	2/8/79	2/23/79
293	West Penn Power Co. Greensburg, Pa.	2/9/79	2/23/79
294	Childscapes, Inc. Atlanta, Ga.	2/12/79	2/23/79
295	Wisconsin Public Service Corp., Green Bay, Wi.	2/12/79	2/23/79
296	M & & Chemicals Inc. Rathway, N.J.	2/9/79	2/23/79
297	Iowa Public Service Co. Sioux City, Iowa	2/12/79	2/23/79
298	Cincinnati Gas & Electric Co. Cincinnati, Ohio	2/12/79	2/23/79
See 22 299	OM Scott & Son (Vol I only)(VolII NFPD) Maryville, Ohio	2/12/79	2/23/79
300	Langdale Co. Valdosta, Ga	2/7/79	2/26/79
301	Ohio Edison Co. Akron, Ohio	2/5/79	2/27/79
See 301, 301 A	Ohio Edison Co., Akron, OH	6/28/79	7/9/79
302	Baltimore Gas & Electric Co. Baltimore, Md.	2/8/79	2/27/79

303	Kootenai Electric Coeur D'Alene, Idaho	2/16/79	2/28/79
304	Wisconsin Electric Power Co. Milwaukee, Wi.	2/15/79	2/28/79
305	C.H. Abrams Lilburn, Ga.	2/12/79	2/28/79
306	San Diego Gas & Electric San Diego, Ca.	2/15/79	2/28/79
307	Department of Transportation(Trans. Bldg) Salem, Oregon	2/16/79	2/28/79
308	Scharf Family Amity, Oregon	1/6/79	2/28/79
309	Ventron Corp. (Chemicals Division) Beverly, Ma. (Confidential Atchs. Withdraw A & B)	2/12/79	2/28/79
310	Missouri Power & Light Co. Jefferson City, Mo.	2/21/79	3/1/79
311	Central Electric Power Cooperative Jefferson City, Mo.	2/26/79	3/5/79
See 312A 312	Benton Rural Rural Electric Assoc. Prosser, Washington	2/15/79	3/2/79
312A	Benton Rural Electric Association Prosser, Washington	3/1/79	3/7/79
313	Kaiser Agricultural Chemicals Savannah, Ga.	2/22/79	3/5/79
314	Tucson Gas & Electric Co. Tucson, Az.	3/5/79	3/8/79
315	Singing River Electric Power Association Lucedale, Ms.	2/28/79	3/8/79
316	White River Electric Power Association Meeker, Colorado	2/27/79	3/7/79

317	Liz Vanleeuwen Halsey, Oregon	2/12/79	3/7/79
318	Bowater Carolina Corp. Catawba, S.C.	2/23/79	3/7/79
319	Yampa Valley Electric Association, Inc. Steamboat Springs, Col.	3/7/79	3/13/79
320	Sonford Products Corp., (Southern Div.) Jackson, Miss.	2/8/79	3/13/79
321	Public Utility District No. 1 of Klickitat Cty Goldendale, Washington	3/9/79	3/13/79
321A	Public Utility District No. 1 of Okanogan Cty. Okanogan, Washington	3/9/79	3/13/79
See 321, A 321 B	Public Util. Distr. No. 1 No. 1 Okanogan, WA.	7/2/79	7/9/79
322	Wasco Electric Cooperative, Inc. Dalles, Oregon	3/12/79	3/20/79
323	Nebraska Public Power Columbus, Nebraska	3/12/79	3/20/79
324	Port Authority of New York & New Jersey New York, N.Y.	3/14/79	3/22/79
325	Savannah Electric & Power Company Savannah, Georgia	UNDATED	3/22/79
326	Orcas Power & Light Company Eastsound, Washington	3/19/79	3/26/79
327	Thyrald H. Finn Rigby, Idaho	3/16/79	3/26/79
328	Dixie Electric Power Assoc. Laurel, Ms.	3/19/79	3/29/79
329	Memphis Light, Gas and Water Division Memphis, Tenn.	3/20/79	3/30/79

330	Columbus and Southern Ohio Electric Co. Columbus, Ohio	3/19/79	3/30/79
331	Poudre Valley Rural Electric Association Fort Collins, Colorado	3/23/79	3/30/79
332	Public Utility District No. 1 of Chelan County Wenatchee, Washington	3/23/79	3/30/79
333	Carbon Power & Light Inc. Saratoga, Wyoming	3/21/79	4/3/79
334	Eugene Water & Electric Board Eugene, Oregon	3/26/79	4/3/79
335			
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337	Dearborn Chemical Chemed Corp., Lake Zurich, Ill.	3/30/79	4/10/79
338	Inter County Rural Elec. Coop. Corp., Danville, Kentucky	4/3/79	4/10/79
339	Craig-Cotetourt Elec. Coop. New Castle, Penna.	4/4/79	4/10/79
340	Crow Wing Coop. Power & Light Co. Brainerd, Minn.	UNDATED	4/10/79
341	Delaware County Electric Coop. Delhi, New York	UNDATED	4/10/79
342	Harkers Island Elec. Corp. Harkers, Island, N.C.	4/3/79	4/10/79
343	Roanoke Electric Corp. Rich Square, N.C.	4/3/79	4/10/79
344	Flint Hills Rural Elec. Coop. Assoc. Inc. Council Grove, Kansas	UNDATED	4/10/79

344A See 344	Flint Hills Rural Elec., Coop., Assn., Inc. Council Grove, Kansas	4/9/79	4/17/79
345	Ohio State University (Forestry Division) Columbus, Ohio	3/26/79	4/10/79
346	Farmers Elec. Coop., Inc. Greenfield, Iowa	4/3/79	4/10/79
347	Continental Divide Elec. Coop., Inc. Grants, New Mexico	4/3/79	4/10/79
348	Springer Electric Coop., Inc. Springer, New Mexico	4/4/79	4/11/79
349	East Ms. Electric Power Assoc. Meridian, Ms.	4/4/79	4/11/79
350	Grundy Electric Coop. Inc. Trenton, Mo.	4/5/79	4/11/79
111A	Tri-County Electric Coop. Portland, Mi.	4/5/79	4/11/79
351	Rio Grande Electric Coop., Brackettville, Tx.	4/5/79	4/11/79
352	Snohomish County Public Utility District No. 1 Everett, Washington	4/3/79	4/11/79
353	Adams Electric Coop., Inc. Gettysburg, Penna.	4/5/79	4/11/79
354	Nebraska Electric Generation & Transmission Coop., Inc. Columbus, Nebraska	4/4/79	4/11/79
355	Public Utility District of Grant County Ephrata, Washington	4/4/79	4/11/79
356	Grand Valley Rural Power Lines, Inc. Grand Junction, Colorado	4/5/79	4/11/79
357	Southern Pine Electric Brewton, Alabama	4/9/79	4/13/79

358	Midstate Electric Coop., Inc. LaPine, Oregon	4/4/79	4/13/79
359	Southeast Electric Coop., Inc. Ekalaka, Montana	4/5/79	4/13/79
360	Halifax Electric Membership Corporation Enfield, N.C.	4/6/79	4/13/79
361	Logan County Co-op Power and Light Assoc. Inc. Bellefontaine, Ohio	4/4/79	4/13/79
362	K.C. Electric Association Hugo, Colorado	4/4/79	4/13/79
363	Tallapoosa River Electric Cooperative LaFayette, Alabama	4/5/79	4/13/79
364	Harney Electric Coop., Inc. Burns, Oregon	4/6/79	4/13/79
365	Kiamichi Electric Coop., Inc. Wilburton, Ok.	4/6/79	4/13/79
366	Tri-County Electric Membership Corp. Goldsboro, N.C.	4/5/79	4/13/79
367	Midwest Electric Inc. St. Marys, Ohio	4/10/79	4/13/79
368	Lincoln Electric Cooperative, Inc. Eureka, Montana	4/10/79	4/13/79
369	Norhteast Missouri Electric Power Coop. Palmyra, Mo.	4/4/79	4/13/79
370	Public Utility District No. 1 of Franklin Cty Pasco, Washington	4/9/79	4/13/79
371	Jo-Carroll Electric Cooperative, Inc. Elizabeth, Ill.	4/4/79	4/13/79
372	Rutherford Electric Membership Corp. Forest City, N.C.	UNDATED	4/13/79

373	Waynw-White Counties Electric Cooperative Farifield, Ill.	4/4/79	4/13/79
374	Douglas Electric Coop., Inc. Roseburg, Oregon	4/6/79	4/13/79
375	Missouri Public Service Company Kansas City, Mo.	3/27/79	4/13/79
376	RSR Elec. Co-op Inc. Milnor, N.D.	4/9/79	4/17/79
377	The Victory Elec. Coop. Assoc., Inc. Dodge City, Kansas	4/9/79	4/17/79
378	United Elec. Coop. Inc. Dubois, Iowa	4/10/79	4/17/79
379	Howard Elec. Coop. Fayette, Mo.	4/9/79	4/17/79
380	Glacier Elec. Coop., Inc. Cut Bank, Montana	4/10/79	4/17/79
381	Okefenoke Rural Elec., Membership Corp., Nahunta, GA.	4/9/79	4/17/79
382	Kandiyohi Coop., Elec., Power Association Willmar, MN	4/9/79	4/17/79
383	Planters Elec., Membership Corp., Millen, GA.	4/5/79	4/17/79
384	Golden Valley Elec., Assoc., Inc. Fairbanks, Alaska	4/5/79	4/17/79
385	Re Sand Mountain Elec., Coop., Rainsville, Alabama	4/9/79	4/17/79
386	Lake Region Elec., Coop., Inc., Hulbert, Oklahoma	4/9/79	4/17/79
387	EMC Haywood Elec., Membership Corp., Waynesville, N.C.	4/11/79	4/17/79

388	Grand Elec., Coop., Inc., Bison, S.D,	4/9/79	4/17/79
389	Union Rural Elec., Association, Inc.,Brighton, Colorado	4/10/79	4/18/79
390	Kotzebue Elec., Assoc., Inc., Kotzebue, Alaska	4/9/79	4/18/79
391	Alger Delta Coop., Elec., Association Inc., Gladstone, MI	4/12/79	4/18/79
392	TRI-County Elec., Assoc., Inc., Plankinton, S.D.	4/12/79	4/18/79
393	C&W Rural Elec., Coop., Association Clay Center, Kansas	4/13/79	4/18/79
394	Slope Elec., Coop., Inc., New England, N.D.	4/12/79	4/18/79
395	Moreau-Grand Elec., Coop., Inc., Timber Lake S.D.	4/3/79	4/20/79
396	Valley Elec., Membership Corp., Natchitoches, LA.	Undated	4/20/79
397	York Country Rural Public Power District York, Nebraska	4/13/79	4/20/79
398	Carroll Elec., Membership Corp., Carrollton, GA.	4/12/79	4/20/79
399	San Luis Valley Rural Elec., Coop., Inc. Monte Vista, Colorado	4/9/79	4/20/79
400	Mitchell Elec., Membership Corp., Camilla, GA.	4/11/79	4/20/79
401	Flathead Elec., Coop., Inc., Power & Light Kalispell, Montana	4/12/79	4/20/79
402	East Central Elec., Assoc., Braham, MN	4/11/79	4/20/79
403	North-Central Elec., Coop., Inc. Attica, Ohio	4/12/79	4/20/79
404	Wells Rural Elec., Co., Wells, Nevada	4/12/79	4/20/79

405	Intermountain Rural Elec., Assoc., Littleton, Colorado	4/12/79	4/20/79
406	Roseau Elec., Coop., Inc., Roseau, MN.	Undated	4/20/79
407	Mountain View Elec., Assoc., Inc., Limon, Colorado	4/9/79	4/20/79
408	Shenandoah Valley Elec., Coop., Inc., Dayton, VA.	4/11/79	4/20/79
409	Sac Osage Elec., Coop., El Dorado Springs, MO	4/9/79	4/20/79
410	Cavalier Rural Elec., Coop., Inc., Langdon, N.D.	4/11/79	4/20/79
411	Wheatland, Rural Elec., Assoc., Wheatland, Wyoming	4/11/79	4/20/79
412	Beauregard Elec., Co-op., Inc., De Ridder, LA.	4/6/79	4/20/79
413	Beartooth Elec., Co-op., Inc., Red Lodge, Montana	4/9/79	4/20/79
414	Warren Rural Elec., Coop., Corp., Bowling Green, KY.	4/12/79	4/20/79
415	Maquketa Valley Rural Elec., Coop., Anamosa, Iowa	4/12/79	4/20/79
416	Pickwick Elec., Coop., Selmer, Tenn.	4/12/79	4/20/79
417	Pearl River Valley Elec., Power Assoc., Columbia, MS.	4/11/79	4/20/70
418	Pea River Elec., Coop., Ozark, Alabama	4/18/79	4/24/79
419	Peace River Elec., Coop., Inc., Wauchula, Fla.	4/17/79	4/24/79
420	Plumas-Sierra Rural Elec., Coop., Inc., Portola, California	4/17/79	4/24/79
421	Covington Elec., Coop., Inc., Andalusia, Alabama	4/18/79	4/24/79

422	TRI-County Rural Elec., Coop., Inc., Mansfield, Pa.	4/17/79	4/24/79
423	Polk Country Rural Public Power District Stromsburg Nebraska	4/9/79	4/24/79
424	Fall River Rural Elec., Coop., Inc., Ahston, Idaho	4/19/79	4/26/79
425	Blue Ridge Elec., Membership Corp., Lenoir,N.C.	4/23/79	4/26/79
426	Bruce Hunt Salem, Oregon	3/20/79	4/30/79
427	Verendrye Elec., Coop., Inc., Velva, N.D.	4/23/79	4/30/79
428	Wise Elec., Coop., Inc., Decatur, TX	4/1/79	4/30/79
429	Cumberland Elec., Membership Corp., Clarksville, TN.	4/20/79	4/30/79
430	Cullman, Elec., Coop., Cullman, Alabama	4/17/79	4/30/79
431	Jackson Country Rural Elec., Membership Corp., Brownstown, Indiana	4/18/79	4/30/79
432	Corn Belt Power Coop., Humboldt, Iowa	4/16/79	4/30/79
433	Sumter Electric Membership Corp., Americus, GA.	4/19/79	4/30/79
434	Lower Valley Power & Light, Inc., Afton, Wyoming	4/19/79	4/30/79
435	Shelby Rural Elec., Coop., Shelbyville, KY	4/20/79	4/30/79
436	Dairyland Power Coop., La Crosse, WI	Undated	4/30/79
437	Cotton Elec., Coop., Walters, OK	Undated	4/30/79
438	Sun River Elec., Coop., Inc., Fairfield, Montana	4/18/79	4/30/79

439	Harrison County Rural Elec., Membership Corp., Corydon, Indiana	4/20/79	5/1/79
440	Edgecombe-Martin County Elec., Membership Corp., Tarboro, N.C.	4/26/79	5/4/79
441	Kosciusko County Rural Elec., Membership Corp., Warsaw, Indiana	4/30/79	5/4/79
442	Jackson Electric Membership Corp., Jefferson, GA.	4/27/79	5/4/79
443	Fairfield Elec., Coop., Inc., Winnsboro, S.C.	4/27/79	5/4/79
444	Barc Electric Coop., Millsboro, VA.	4/30/79	5/4/79
445	Habersham Electric Membership Corp., Clarkesville, GA.	4/24/79	5/4/79
446	Western Illinois Elec., Coop., Carthage, IL	4/24/79	5/4/79
447	Hickman-Fulton Counties Electric Coop., Corp., Hickman, KY	4/30/79	5/4/79
448	United Power Association Elk River, MN.	4/23/79	5/4/79
449	Blue Grass Recc Nicholasville, KY.	Undated	5/4/79
450	Rural Elec., Convenience Coop., Co., Auburn, IL.	4/26/79	5/4/79
451	Meriwether Lewis Elec., Coop., Centerville, TN	4/27/79	5/8/79
452	Washington State Univ. Pullman, Washington	5/3/79	5/9/79
453	American Institute of Timber Construction Englewood, Colorado	5/2/79	5/9/79
454 454A	National Rural Elec., Coop., Accoc., Washington, D.C.	3/29/79	5/11/79

455	Joe Wheeler Elec., Membership Corp., Hartselle, Alabama	4/30/79	5/11/79
456	Oliver B. Wilbers Umpqua, OR	4/7/79	5/17/79
457	Dairyland Power Coop., LA Croose, WI	5/10/79	5/17/79
458	Oliver-Mercer Elec., Coop., Inc., Hazen, ND	5/9/79	5/17/79
459	Petit Jean Elec., Clinton, Arkansas	5/7/79	5/17/79
460	Eastern Iowa Light & Power Corp., Wilton, Iowa	5/9/79	5/21/79
461	Cookson Hills Elec., Coop., Inc., Stigler, OK	4/26/79	5/2/79
462	Coos Curry Elec., Coop., Inc., Coquille, Oregon	5/9/79d	5/23/79
463	Navopache Elec., Coop., Inc., Lakeside, Arizona	Undated	5/24/79
464	Betz Labs, Inc., Trevose, PA.	5/9/79	6/5/79
465	Green River Elec., Corp. Owensboro, KY	6/5/79	6/14/79
466	Northern Lights, Inc., Sandpoint, Idaho	6/7/79	6/15/79
467	Dow Chemical Co., Midland, MI	6/5/79	6/22/79
468	Concordia Elec., Coop., Inc., Ferriday, LA.	6/11/79	6/22/79
469	Alabama Power Co., birmingham, ALA.	6/15/79	6/22/79
470	U.S. Dept. of Agri. Forest Serv., Asheville, N.C.	6/15/79	6/28/79
471	MS. Power Co., Gulfpost, MS.	6/20/79	6/28/79

472	Iowa Southern Util. Co., Centerville, Iowa	7/3/79	7/9/79
473	DOD, OASD (Marienthal) Washington, D.C.	6/27/79	7/12/79
474	Memphis Light, Gas & Water Div. Memphis, TN	7/11/79	7/19/79
475	Lincoln Elec., Coop., Inc., Eureka, Montana	6/25/79	7/19/79
476	Montana State Univ. Bozeman, Montana	7/16/79	8/2/79
477	Gulf States Util, Co. Beaumont, TX.	8/2/79	8/10/79
478	McKenzie Elec., Coop., Watford, N.D.	7/13/79	8/10/79
479	Cleveland Utilities Cleveland TN.	7/6/79	8/10/79
See 454 A	National Rural Elec., Coop., Washington, D.C.	8/22/79	8/22/79
480	Ailing House Pest Control Carmel, CA. Thru Univ, of CA.	9/11/79	9/17/79
481 481A	National Forest Products Assoc.	11/30/79	12/10/79
482	Friends of the Earth Washington, D.C.	2/21/80	2/21/80
483	International Woodworkers of America, Portland Oregon	3/6/80	3/10/80
484	International Brotherhood of Electrical Workers	3/31/80	4/24/80
485	American Railroads Washington, D.C.	4/25/80	5/2/80

APPENDIX 2:

APPENDIX 2

CONCEPTS THAT WERE CONSIDERED AS POSSIBLE REGULATORY OPTIONS FOR THE WOOD PRESERVATIVE PESTICIDES

		Creosote/Coal Tar	Inorganic Arsenicals	Penta
1.	Cancel all wood treatment formulations.	x	x	x
2.	Cancel non-pressure treatment.	x	x	x
3.	Cancel all homeowner uses, and over-the-counter sales of wood treatment formulations.	x	x	x
4.	Restrict use of treated wood where contact with food products may occur e.g. potato bins, pig pens (minor uses).	x	x	x
5.	Fully automated (closed system) treatment processes (functional equivalent of the Madison, Virginia inorganic arsenic plant, which represents best available technology).	x	x	x
6.	Install automated cylinder doors.	x	x	x
7.	Require closed system on mixing tanks.	x	x	x
8.	Require isolation of treatment operator in air-purified booth.	x	x	x
9.	Require epidemiology studies.	x	x	x
10.	Set air standards.	x	x	x

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		Creosote/Coal Tar	Inorganic Arsenicals	Penta
11.	Set surface residue standards.	x	x	x
12.	Require all mechanical, instead of manual, mixing.	x	x	x
13.	Restrict use to certified applicators (plant and over-the-counter activities).	x	x	x
14	Restrict dipping and painting to industrial and commercial applicators only.	x	x	x
15.	Require ventilation in mixing room.	x	x	x
16.	Require appropriate respirator when entering the cylinder for cleaning or during manual opening of the door.	x	x	x
17.	Require shower facilities.	x	x	x
18.	Lower maximum levels for contaminants in technical products and formulations (e.g. HxCDD, total dioxin, HCB).	x	x	x
19.	Require a longer drying time of wood after treatment.	x	x	x
20.	Require an additional vacuum treatment cycle.	x	x	x
21.	Specify formulation types (examples: require bricks and/or beads of appropriate sizes, pre-mixed liquid).	x	x	x

		Creosote/Coal Tar	Inorganic Arsenicals	Penta
22.	Specify packaging types (e.g. size of containers, bags, drums).	x	x	x
23.	Wear appropriate protective clothing when working in the area of the cylinder.	x	x	x
24.	Require work boots and clothes to be left at plant.	x	x	x
25.	Require wearing of appropriate gloves at all tiems.	x	x	x
26.	Require warning signs, safe lines in plant work areas and on chemical tanks.	x	x	x
27.	Require lunches to be eaten away from work area.	x	x	x
28.	Require trenching of plant area to control runoff.	x	x	x
29.	Require recycling of waste water, waste oil and cooling water.	x	x	x
30.	Require holding ponds and/or lagoons.	x	x	x
31.	Require annual physicals and medical record keeping.	x	x	x
32.	Require educational briefing on use and handling of chemicals.	x	x	x

		Creosote/Coal Tar	Inorganic Arsenicals	Penta
33.	Require extensive warning labels on over-the-counter formulations.	x	x	x
34.	Require distribution of brochures with over-the-counter formulations.	x	x	x
35.	Specify that office staff be away and upwind from work area.	x	x	x
36.	Distribute educational and safety information with the treated wood at the distributor/consumer level.	x	x	x
37.	Do not eat, smoke, drink or use food-dispensing machines except in designated safe areas (Slight variation for homeowner label).	x	x	x
38.	Do not remove work clothes from the plant; work clothes must be cleaned industrially (Commercial labels).	x	x	x
39.	Wash work clothes separately from other laundry (Home labels).	x	x	x
40.	Dispose of waste products that contain wood preservatives, in a manner that will not cause a significant adverse effect on humans or the environment.	x	x	x

		Creosote/Coal Tar	Inorganic Arsenicals	Penta
41.	Include aid and antidote information on any label associated with wood preservatives.	x	x	x
42.	Above-ground uses of this preservative will be phased out over the next five years as new sealants are developed.	x	x	x
43.	Do not use this wood preservative on any wood destined for interior use. The only exception to this is for use on pentachlorophenol-treated millwork, such as indoor-outdoor windows and doors which will also be painted. Paint or other sealant over the pentachlorophenol treated wood is essential for sealing the toxicant into the wood.	x	x	x
44.	Wear respirators capable of removing organic vapors when opening treatment cylinder.	x		
45.	All applicators and users of creosote or creosote-treated products be required to wear gloves made of materials impervious to creosote, such as neoprene or rubber.	x		
46.	Anyone entering a cylinder for any purpose must wear a full suit of protective clothing including a respirator and creosote-impervious gloves.	x		
47.	Anyone entering a treatment cylinder for more than a few seconds at a time must wear a full suit of protective clothing including a respirator and creosote-impervious gloves.	x		

		Creosote/Coal Tar	Inorganic Arsenicals	Penta
48.	Require coating of pilings and other creosote-treated structures with plastic.	x		
49.	Specify minimum time before opening cylinder to increase evacuation of pesticide.	x		x
50.	Require enclosed forklifts which are used for moving treated lumber.	x		x
51.	Surface residues for inorganic arsenic should not exceed 10 ug/cm^2 (ug as arsenic) for human contact uses (park benches, playground equipment, stadium seats, outdoor sanitary facilities, etc.). Surface residues should not exceed 100 ug/cm^2 on non-contact uses (fence posts, barn sidings, etc.).		x	
52.	All applicators applying and handling wood freshly treated with inorganic arsenical compound must wear gloves impervious to the preservative.		x	
53.	Restrict or prohibit women of child-bearing age from applying the preservatives.		x	x
54.	Cancel or phase out ACA.		x	
55.	Cancel or phase out FCAP formulations.			
56.	Specify sealing of surface of wood which may come into contact with the general population (e.g. playground equipment public benches).		x	x
57.	Require special treating and cleaning procedures for ACA formulations.		x	

	Creosote/Coal Tar	Inorganic Arsenicals	Penta
58. Require ACA-treated wood to be sealed or painted.		x	
59. Require trademarks etc. to be stamped rather than burned into the treated wood.		x	x
60. Include OSHA air standards for arsenic on labels.		x	
61. Restrict people from walking on the drip pad area (where freshly treated wood drains).		x	
62. Products containing pentachlorophenol concentrations greater than 5% may be used only by certified pesticide applicators.			x
63. Respirators designed to trap pentachlorophenol vapors, or reduce exposure to them, must be worn by workers in the mixing room and by employees who are opening cylinder doors after treatment.			x
64. Concentrations of pentachlorophenol in the air of the mixing room may not exceed 0.02 mg/cubic meter.			x
65. Do not dispose of pentachlorophenol bags by burning as this produces dioxins. Transport pentachlorophenol in reusable drums or by other acceptable means.			x
66. Lower maximum levels of dioxin isomers and HCB in technical pentachlorophenol.			x

	Creosote/Coal Tar	Inorganic Arsenicals	Penta
67. Pentachlorophenol-treated wood may not be used in the construction of structures such as benches, stadium seats, play ground equipment, and outdoor toilets or other structures, where there is the potential for human contact.			x
68. Over the next five years, pentachlorophenol-treated wood will cease to be used in construction of structures such as benches, stadium seats, playground equipment, outdoor toilets, and other structures where there is the potential for human contact unless an effective sealant can be developed.			x
69. Cancel all homeowner uses.			x

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